SCIENCE ABSTRACTS.

Section A.—PHYSICS.

JULY 1910.

GENERAL PHYSICS.

867. *On Damping a Balance.* **G. Lippmann.** (Comptes Rendus, 150. pp. 1568–1569, June 13, 1910.)—Suspend about 2 gm. by a silk thread inside the case of a balance. A lever can be used to push the thread against the balance beam and so damp its movements. In the case of a very sensitive balance this adjunct will enable the time of weighing accurately to be reduced to one-tenth, say from 5 min. to 30 sec., without loss of accuracy.

P. E. S.

868. *A New Gravitation Apparatus.* **V. Crémieu.** (Comptes Rendus, 150. pp. 863–866, April 4, 1910.)—The principle involved has been discussed already by the author [see Abstracts Nos. 1157 and 1994 (1909)]. Here he shows how gravitation can be studied by observations on the angular displacement brought about by pendular displacement; this pendular movement being due to the pull of a large mass on a small one hung by a fine fibre. Torsion is produced by any unbalanced moment in the case of a gravitation torsion balance, and the author considers that "in a torsion balance of the Cavendish type it is impossible to know to more than 1/1000 the value of the couple produced in the fibre." P. E. S.

869. *Transformer for Solution of Spherical Triangles.* **K. Schwarzschild.** (Zeitschr. Instrumentenk. 30. pp. 75–80, March, 1910.)—Describes a system of curves which can be used for various purposes; *e.g.*, transforming from altitude and azimuth to declination and hour-angle, obtaining the longitude from the altitude of a star for a known latitude, &c.; a method is also given for determining in a balloon the place over which it is passing. If a point in the sky has altitude z and azimuth a, its distance from the west-point being ρ, and the angle the direction of ρ makes with the horizontal being γ, then $\sin\rho\cos\gamma = \cos z\cos a$, $\sin\rho\sin\gamma = \sin z$, $\cos\rho = \cos z\sin a$ ... (1). The corresponding formulæ for the declination (δ) and hour-angle (t) in terms of

ρ' and γ' give for these latter $\sin\rho'\cos\gamma' = \cos\delta\cos t$, $\sin\rho'\sin\gamma' = \sin\delta$, $\cos\rho' = \cos\delta\sin t$ ... (2). Hence $\rho = \rho'$ and γ' must be the angle between the direction of ρ and the equator; therefore $\gamma = \gamma' + (90 - \phi)$ ... (4), where ϕ is the geographic latitude. The transformer described is based on the relations (1) and (4). We have $\sin\rho\sin\gamma = \sin z = \text{const.}$, and $\tan\rho\cos\gamma = \cot a = \text{const.}$ These curves are plotted on the same diagram for intervals of 1° from 0° to 90°. Each point of the heavens corresponds to two points of the diagram, according as we deal with horizontal or equatorial co-ordinates. Both points have the same abscissa x, and their ordinates y differ by an amount $(90^\circ - \phi)$. The method of use of the transformer is fairly simple, but does not admit of brief abstract. A. W.

870. *Impact Testing Machine.* (Engineering, 89. p. 572, May 6, 1910.)—The Cambridge Scientific Instrument Co. have introduced a modified form of the impact testing machine originally devised by Stanton. The hammer is attached to the free end of a hinged lever, and is raised by one end of a rod resting on a roller, which is capable of lateral movement so that the lift can be varied. The other end of the rod is driven by a crank so that the free end has an elliptical motion, raising the hammer and then allowing it to fall. One end of the specimen is held on a knife-edge by means of a spring, and the other end is held in a chuck flexibly connected by a universal joint to the driving gear, which is fitted with an escapement. The driving gear is arranged to turn the specimen through 180° between two consecutive blows. When the specimen breaks, the fall of the hammer opens the electrical circuit in the motor driving the machine. A counter is provided to determine the total number of blows struck. F. C. A. H. L.

871. *Anomalous Effects of First Loading a Wire. Effects of Bending Overstrain in Soft Iron Wires.* **A. I. Steven.** (Phil. Mag. 19. pp. 619–626, April, 1910.)—The so-called anomalies are only special cases of the loss of elasticity consequent upon severe overstrain, and the author concludes that any theory which explains one type of effect will be equally applicable to this one. Every wire after manufacture is subjected to non-homogeneous overstrain by being wound on a circular bobbin of comparatively small dimensions. It is probable that, if the wire remains on the bobbin, part of the internal stress disappears before the wire is tested. When the wire is wound off the bobbin for testing another set of stresses is superposed. The processes of bending and unbending do not exactly neutralise each other. In the experiments soft iron wire was used, of average diam. 0·0364 cm. Extension of length was measured by two microscopes. Load extension curves given show effect of three successive tests on wire. The same type of curve always resulted (with cylinders of four different diams.) when a wire suffered circular deformation. Other tests show the similarity between behaviour of wire and iron and steel rods after overstrain. Tests on overstrained wires subjected to low heat treatment showed slight variation to similar tests made on steel bars. C. A. M. S.

872. *Elastic Properties of Platinum-Iridium Wires.* **K. E. Guthe** and **L. P. Sieg.** (Phys. Rev. 30. pp. 610–633, May, 1910.)—Previous investigation by K. E. Guthe (Phys. Rev. 26. p. 201, 1908) showed that platinum-iridium wires deviated from the ordinary wires in elastic behaviour when used for experiments on torsional vibrations. The object of this investigation was to extend observations to larger amplitudes, and to study the influence of different percentages of Ir upon elastic properties of Pt-Ir wires. The results of the investigation show that (1) Pt-Ir wires which contain over 30 per cent. Ir show striking peculiarities in their elastic behaviour, which become more marked the higher the percentage of Ir. (2) For small amplitudes the period of torsional vibration is nearly proportional to the amplitude, but for larger amplitudes the rate of increase of the period becomes smaller, and for very large amplitudes the period tends towards a constant value. (3) The log. decrement increases with the amplitude, reaches a maximum, after which it again decreases, and probably reaches a minimum for very large amplitudes. The maximum is the more pronounced the larger the original distortion. (4) If the wire has been allowed to rest some time before the torsional vibrations are produced, the total number of vibrations necessary to bring the system to rest is the smaller the larger the initial amplitude. (5) When tested by the static method the wires closely obey Hooke's law, but there was a slight hysteresis effect. The torsional moment calculated from the static experiment is larger than the largest torsional moment found by the dynamic method. Former experiments had shown that previous heat treatment greatly influenced the elastic properties, and since it was desired to have all wires in the same condition, each wire was annealed under the load it was to carry by sending a current of 2 amps. through it. The temperature was raised until there was a bright yellow heat. Even at high temperatures the wire supported a considerable load. Different moments of inertia of the moving system were tried, but this did not change the character of the curves. The phenomenon was greatly influenced by the conditions under which the vibrations were produced. The necessary conditions for repeat experiments seem to be that the temperature and initial amplitude is exactly similar. The slope of amplitude-period curves does not alone depend upon initial amplitude, but also upon whether or not the wire had been kept for some time in a twisted condition before being released, or had been kept swinging continuously before the experiment was started. In each successive series the wire makes about 50 vibrations less in reaching an amplitude of 5°. It seems very difficult to draw wires containing more than 40 per cent. of Ir, since the material becomes extremely brittle. The wires are very hard.

C. A. M. S.

873. *Mild Steel Tubes in Compression and under Combined Stress.* **W. Mason.** (Inst. Mech. Engin., Proc. 4. pp. 1205–1236, Oct.–Dec., 1909. Engineering, 88. pp. 867–871 and 872; Discussion, pp. 845–849, Dec. 24, 1909. Engineer, 108. pp. 671–674, Dec. 24, 1909.)—Work described in the paper is largely upon comparative yield-point strengths in compression and shear. Loading was accomplished by subjecting the tubes to compressive stress (obtained by Wicksteed testing-machine) and hydraulic pressure in the interior of tube. Tests on the tubes were also made as follows: Simple axial tension, simultaneous axial and hoop tension, simple axial compression, simultaneous axial compression and hoop tension, and simultaneous axial and hoop compression. Specimens were cut from solid-drawn mild-steel tubes of 3 in. bore and about 0·08 in. thick, and of 2¾ in. bore and about 0·128 in. thick, tests being made both on tubing as supplied, and also after careful annealing. The strains were measured by a Ewing extensometer. The value of Young's modulus calculated from the compression tests ranged from $28{\cdot}2 \times 10^6$ to $30{\cdot}2 \times 10^6$ lbs. per sq. in. In all the specimens of the tube of No. 10 gauge wall-thickness, the extensometer showed a very definite yield-point which was always simultaneous with the appearance of "Luder's lines" on the

surface. In all the tests made in simultaneous compression and hoop tension, these lines always became visible on the specimens at the yield-point, due to the disturbance of the scale on the tube as the metal yielded. Photographs given show the markings. The lines very nearly correspond with the planes of max. shear. The experiments show an approximate agreement between the max. shear-stress at the yield-point in compression and the yield-point stress in pure shear, the mean difference in the tests of annealed specimens being about 8 per cent. C. A. M. S.

874. *Influence of Elastic Extension of Hollow Cylinders on the Determination of High Pressures.* **W. Meissner.** (Zeitschr. Instrumentenk. 30. pp. 187–189, May, 1910. Communication from the Physikal.-Techn. Reichsanstalt.)—This relates to the calculation of the correction factor to be used with the Amagat manometers employed in the National Bureau for testing manometers. In these instruments a piston works in a nickel steel cylinder. Pressure in the latter will cause an increase of diam. This increase in diam. will be given by—

$$\epsilon = \frac{p}{\mathrm{E}} \frac{r_1^2}{r_a^2 - r_1^2} \left(\frac{m+1}{m} \frac{r_a^2}{r_1^2} + \frac{m-1}{m} \right),$$

where p is the pressure, E Young's modulus; r_1 and r_a are the inside and outside diams. respectively, and $1/m$ is Poisson's ratio. The nickel steel (25 per cent. Ni) had a value for E $18{\cdot}6 \times 10^5$ kg. per cm.², and a value m of 10/3. Whence we derive that the correction factor—

$$k_1 = -2\epsilon p = -\frac{p^2}{\mathrm{E}} \frac{2r_1^2}{r_a^2 - r_1^2} \left(1{\cdot}8 \frac{r_a^2}{r_1^2} + 0{\cdot}7 \right).$$

This value is given in tabular form for the four cylinders in general use. At 20 kg./cm.² it amounts to about $-0{\cdot}001$, while at 1000 kg./cm.² the value of k is $-1{\cdot}65$ kg./cm.². C. A. M. S.

875. *Compound Stress Experiments.* **C. A. M. Smith.** (Inst. Mech. Engin., Proc. 4. pp. 1237–1277; Discussion, pp. 1278–1316, Oct.–Dec., 1909. Engineering, 88. pp. 849–853; Discussion, pp. 845–849, Dec. 24, 1909. Engineer, 108. pp. 697–700, Dec. 31, 1909.)—The author discusses the results of experiments on solid steel bars, particularly in their bearing upon the design of crankshafts. The systems of loading employed were: (1) compression, (2) torsion, (3) combined compression and torsion, (4) tension, and (5) combined tension and torsion, the max. stress at failure in each case being noted. Previous work on the subject is discussed and the author considers that Guest's max. shear stress law explains the elastic failure of mild steel under all conditions of loading. In the experiments, solid steel bars were adopted instead of tubes, the latter being unsatisfactory for many reasons, their only advantage being that in a torsion test the stress distribution is uniform. Strains were measured by means of a sphingometer. No difficulty was experienced in noting the yield-point; in mild steel this coincided with the elastic limit, which, in the author's opinion, points to the homogeneity of the material. Homogeneous material under non-axial loading showed after the yield-point an "elastic limit effect" during which the mean extension for equal increments of load slowly increases. After the first yield the "time effect" becomes very marked. A large number of tests were carried out on alloy steels, but the results were not regarded as satisfactory because of the difficulty experienced in obtaining duplicate results. Every

specimen had an elastic limit as distinct from a yield-point. Some of the tests, however, indicated that nickel steel obeyed Guest's law. The general conclusions arrived at from the experiments are as follows: (1) The elastic failure of mild steel does not depend upon the value of the max. principal stress nor strain, but takes place at a definite shear stress. (2) Guest's law, which is approximately correct for mild steel tubes loaded in tension and torsion, applies to the same material loaded in compression and torsion. (3) The "elastic limit effect" noticeable during tension, torsion, and compression tests is probably due to faults in applying the load and in measuring the strains. (4) The ratio of max. to mean direct stress is greater than is usually considered to be the case. (5) The use of spherical grips does not ensure axial loading, which probably accounts for the discrepant results obtained in measuring elastic limit. (6) The ratio of the working stresses for mild steel in tension and shear should be 2:1 and not 5:4 as is generally stated. Four appendices accompany the paper, the first showing the method of working out a combined stress test, the second proving that the mean extension of the three strips of the sphingometer is equal to the extension of the specimen as a whole, the third shows the method of determining the max. stress, while the fourth describes some experiments on the method of gripping specimens. While spherically seated grips are preferable to V-grips, they do not entirely eliminate eccentric loading. In the *discussion*, **Guest** and **Mason** defended the use of tubes of a proper character. **Stromeyer** considered that in the sphingometer the coiled strips should be of the same material as the test-piece, in order to obviate errors due to changes of temperature. **Goodman** showed that divergence from axial loading was not common to all testing machines, and suggested that much light could be thrown on this subject by working out the results of actual fractured crankshafts. **Gulliver** considered it questionable how far a theory applicable to isotropic material could be applied to an assemblage of crystal aggregates of irregular size and shape and of random orientation like mild steel. **Osmond** pointed out that mild steel is heterogeneous, consisting of a mixture of ferrite, pearlite, sulphides, oxides, and silicates, while copper and its alloys are frequently of great purity. The explanation of the fact that all metals except mild steel possess yield-points as distinct from elastic limits must therefore be sought for in different directions. The yield-point of mild steel appeared to be a phenomenon peculiar to iron, and might be attributed to allotropic modification brought about by strain. F. C. A. H. L.

876. *Stress-lines and Stream-lines.* (Engineering, 89. pp. 303–306, March 11, 1910.)—It is shown that although there is an analogy between stress-lines and stream-lines (or equipotential lines corresponding to the flow of an electric current through a conducting plate, or to the film of a viscous fluid between two glass plates) yet the analogy is very imperfect. The results obtained by Kernot (Victorian Inst. of Engineers, 1901) are considered to be in all probability erroneous. To get the stream-lines corresponding to a given series of stress-lines, it will, in general, be necessary to make use of a heterogeneous conductor. The stress-lines for a piece of uniform material 3·14 in. wide and 10 in. long with an applied load at each end varying uniformly from zero up to 3·14 lbs. per sq. in. are drawn. The stream-lines for an electric current fed into a similar strip at one end and withdrawn at the other, so that the current varies from zero up to 3·14 amps. per sq. in., are also drawn; the plate is taken of uniform conductivity: the two diagrams are quite different. By means of Fourier's series the stream-lines are exactly calculated. Both John Smith (Brit. Assoc., 1906) and Hele-Shaw (Junior Inst. of Engineers, 1907) assumed a close analogy between stream-lines and stress-lines. In cases of irrotational strain there is, however, a perfect analogy between the flow of a current in a conducting sheet and the displacement of the various points of that sheet when exposed to an irrotational strain. It is finally shown that illogical conclusions have been drawn concerning the analogy between stress-lines and stream-lines. They will only be analogous in a conductor of uniform resistance when the stream-lines are parallel to the axis and uniformly spaced; they cannot represent with accuracy the strain or stress-lines elsewhere. The magnitude of the error involved is not easy to estimate, but comparisons of the diagrams show that it is not small. C. A. M. S.

877. *Moments of Inertia.* **W. R. Cassie.** (Phys. Soc., Proc. 21. pp. 497–499; Discussion, p. 500, Oct., 1909.)—Describes a method of measuring accurately the moment of inertia of a bar. The beam of a balance is made in the shape of a trough, and the knife-edges for the pans and the beam are in one plane. The beam carries two double wedges forming **V**'s in which the inertia bar can rest. These wedges are actuated by right- and left-handed screws, so that the bar may be raised, without altering the distribution of matter along the beam, until the equilibrium is neutral. The process of measuring the moment of inertia of a bar by this apparatus is as follows: (1) Bring the balance to neutral equilibrium by adjusting a gravity bob. (2) Hang a known weight W from a knife-edge immediately below that of the beam and take the time, t_1, of a small oscillation. (3) Put equal weights Q in the scale-pans and take the period, t_2. (4) Remove the weights Q and W and put the bar (of inertia I) in the trough, and adjust again to neutral equilibrium by means of the screws which move the wedges. (5) Hang on the weight W and take the period, t_3. (6) Measure a, the length of the arm, then $I = 2Qa^2(t_3^2 - t_1^2)/(t_2^2 - t_1^2)$. In the *discussion*, **Stroud** described a method of determining moments of inertia used in the University of Leeds. In this method two vibrators perpendicular to one another are used, and they can be arranged to produce a Lissajou figure. The horizontal vibrator carries a vertical slit, and *vice versâ*; and as the two slits are placed one behind the other, a small spot of light can be seen through the combination. The vertical vibrator consists of a stout metal framework supported by a torsion wire, and carrying a platform upon which the body whose moment of inertia is required can be placed. The time of swing of this vibrator is then adjusted (by the addition of rings of known moment of inertia) to be equal to that of the horizontal vibrator, so that the Lissajou figure is invariable. The body is then placed upon the platform, and inertia rings are removed till the Lissajou figure is reproduced or nearly so. Accurate observations are then taken of the number of oscillations required to complete a cycle with inertia rings slightly below and above the correct value, which is got by interpolation. The vibrators are kept in continuous oscillation by an electromagnetic make and break. **Lees** observed that Stroud's method did not seem capable of giving very accurate results on account of want of homogeneity of the rings. A. W.

878. *Experiments on Strength Properties of Reinforced-Concrete Beams.* **W. C. Popplewell.** (Inst. Civ. Engin., Proc. 177. pp. 177–192, 1908–1909.)—The experiments described were carried out at the Manchester School of Technology. Eight specimens were tested, each being 11 ft. long, 8 in. wide,

and 10½ in. deep over all. The concrete used was similar in all cases, being a mixture of 1 part standard specification Portland cement to 5 parts of an aggregate consisting of 6 parts broken granite, 2 parts Leighton-Buzzard sand, 1 part stone dust. Four methods of reinforcement were employed: (1) 4 straight ½-in. round bars, no mechanical fixing; (2) the same, ends bent up; (3) middle third straight, ends bent up to take shear stress; (4) the same, with ends bent over to give mechanical hold. An Amsler-Laffon beam-testing machine was employed, the load being applied in two places to give stress distribution approximating to that obtained with uniformly distributed load. Crushing tests on the concrete carried out at ages varying from 4 to 10½ months gave an average max. value of 2220 lbs. per sq. in., while the steel had a yield-point of 19·5 tons per sq. in. and a max. strength of 26·6 tons per sq. in. Young's modulus had an average value of about 3,000,000 for the concrete and 32,000,000 for the steel. Tests on the beams showed five characteristic points in the load deflection curve. The first corresponded to the limit of proportionality in the concrete, and the second the commencement of failure of the concrete in tension. Between the second and third point, known as the "readjustment stage," the whole of the tensile stresses are transferred to the steel. At a fourth point failure begins to occur, while complete breakdown takes place at a somewhat higher load. All the tests agreed fairly well with one another. A series of tests were carried out to determine the position of the neutral axis. Strain measurements were taken by a Martens mirror extensometer at intervals of 1 in. down the beam; 11 sets of readings in all. By plotting a curve, the position of zero extension corresponding to the position of the neutral axis was determined. The general conclusions can be summarised as follows: (1) The four older beams, when compared with the four newer ones, show to advantage in all respects. (2) In the older beams, mechanical hold had the advantage that the beam kept together even after failure, but otherwise there was very little difference. Sloping reinforcement increases the deflection. (3) For low loads the neutral axis is half-way down the beam, and approaches compression force as load increases. (4) Up to the first crack, the strain of the concrete is proportional to distance from neutral axis. (5) The ordinary assumptions give a beam rather stronger than is necessary. The calculated compressive stress in the concrete at failure is considerably higher than that obtained from direct experiment. But the values obtained by direct experiment and by calculation for the steel agree very closely. C. A. M. S.

879. *Experiments on the Flow of Rocks. I. The Flow of Marble.* **F. D. Adams** and **E. G. Coker.** (Amer. Journ. Sci. 29. pp. 465–487, June, 1910.)—Contains results obtained by study of the flow of marble under widely varied conditions of pressure, temperature, and time. The investigation was extended to a number of fine-grained and more or less impure limestones; to crystalline dolomites; and then to a series of typical plutonic intrusives—diabase, essexite, and granite. Experiments were made to accurately measure the loads required for the deformation of standard columns of these and other rocks. This paper contains details of methods used in all the investigations and the results on marble; subsequent papers will give results for some of the other rocks. The apparatus employed for testing was heavy tube of steel, accurately bored out, into which fitted a very accurately turned or ground specimen of rock. Pistons of hardened chromium-tungsten steel were inserted in the ends of the tube. A great lateral resistance was thus obtained, and its value could be varied by altering the thickness of the walls

of the tube. Rock columns used for experiments were in most cases about 0·814 in. diam. and 1·56 in. long. High temperatures, up to 1000° C., were used and a special stove was devised. The following conclusions were arrived at as a result of the experiments: (1) Marble, when deformed at ordinary temperatures, will flow readily by distortion of the original calcite grains, accompanied, if the differential resistance be low, with the development of a certain amount of cataclastic structure. (2) The marble, when deformed at ordinary temperatures, will increase in strength if allowed to rest. (3) The marble, if deformed at ordinary temperatures, will be much stronger if the deformation be carried on slowly than if the deformation be rapid. There is reason to believe that with the extreme slowness of deformation to which the rock is subjected in nature, and the long rest it subsequently undergoes, the change in shape would be accomplished without any loss in strength. (4) If the deformation be carried on at a higher temperature, the calcite develops freer movement on its gliding planes, and the deformed rock will be relatively stronger than if deformed at the ordinary temperature. (5) Under the conditions to which the rock was subjected in these experiments—although not under all conditions—the presence of water has no recognisable influence on the character of the deformation. (6) The specific gravity of the rock was not increased by the pressure to which it was subjected during deformation. In the arrangement of the apparatus the chief object was to reproduce, more or less accurately, the conditions of pressure which obtain in the deeper part of the earth's crust. C. A. M. S.

880. *Variation of Disc Resistance with Temperature in Water.* **A. H. Gibson.** (Phil. Mag. 19. pp. 513–516, April, 1910.)—A possible law of the variation of disc resistance with temperature may be deduced theoretically, assuming that the resistance of each element of the rotating surface is proportional to the same power n of its velocity, and to some power of the viscosity, μ, and of the density ω of the fluid, both of which vary with temperature [see Abstract No. 605 (1909)]. On these assumptions it follows that the resistance is probably proportional to $\mu^{2-n}\omega^{n-1}$; and to test the validity of the reasoning, a series of experiments was carried out by the author on discs 12 in. in diam. rotating in a closed casing, with different values of n, and with a range of temperature from 60 to 160° F. The values of n were determined in each case from a preliminary series of experiments carried out at as nearly as possible uniform temperature, all these results being corrected to 65° F. by an application of the foregoing hypothetical formula. The following values were obtained: Series A—12-in. brass disc in smooth casing with ⅛ in. side clearance, $n = 1·786$. Series B—12 in. brass disc in rough cast-iron casing with ⅛ in. side clearance, $n = 1·800$. Series C—12 in. brass disc with radial vanes with ⅛ in. side clearance, $n = 1·950$ The results of the temperature-variation experiments are given in tabular form for the three discs, and curves are plotted; from these it appears that the theoretical curves fit the experimental results so closely as to justify the adoption of the formula: (Resistance at $t°$ F.) = (Resistance at 65° F.) $\times (\mu_t/\mu_{65})^{2-n}(\omega_t/\omega_{65})^{n-1}$. The results show that the resistance diminishes with an increase in temperature, the amount of the variation with a given temperature-difference increasing as the temperature diminishes and also as n diminishes. Its value in the neighbourhood of 65° F. with a polished brass disc ($n = 1·8$) is about ⅓ per cent. per 1° F. When $n = 1·9$, this falls to ¼ per cent. per 1° F., and when $n = 2·0$ it becomes inappreciably small. [See Abstract No. 876B (1910.)]

A. W.

881. *Hydraulic Rams.* **H. Lorenz.** (Phys. Zeitschr. 11. pp. 284–288, March 15, 1910.)—A mathematical paper dealing with the theory of hydraulic rams. From the theory developed it is possible to calculate beforehand how a ram will work, especially the delivery of useful water and the consumption of the "driving" water, as well as the number of strokes per min., from which the efficiency of the whole arrangement can be obtained. Moreover, it is shown that the working is conditioned particularly by the charge of the outlet valve, which may vary between two limits. Between these two limits the efficiency falls with increasing valve charge from 1 down to 0, while at the same time the useful and "driving" water consumption for each stroke, and therefore the duration of the stroke, increase from 0 upwards. A. W.

882. *Flow of Water over Triangular Notches.* **J. Barr.** (Engineering, 89. pp 485–487 and 488, April 8, and p. 478, April 15, 1910.)—The primary objects of the investigation were the verification of the formula $Q = cH^{5/2}$ for the flow of water over a right-angled triangular or V-shaped notch, and the experimental determination of the values of the coefficient c in that formula. Thomson's experimental results are first discussed, and then an exhaustive series of experiments are described with the aid of numerous tables and diagrams. Particular attention was paid to the effect on the flow of (1) the condition of the up-stream surface of the notch-plate; (2) width and depth of the channel of approach both separately and together; (3) discontinuity in the up-stream surface of the notch-plate. It was found that the coarser the surface of the notch-plate the greater was the discharge. In order that the flow may be independent of the channel width the latter must be at least eight times the head. The effect of making the channel shallower is to slightly diminish the discharge, but this effect disappears if the channel depth is about three times the head with a 3-in. head, and about four times the head with a 4-in. head. With the floor of the channel level with the vertex of the notch and a very narrow channel the increase in the flow produced by the presence of the sides is, accidentally, very nearly equal to the diminution produced by the skin friction, so that the coefficients have approximately the values which they have for the full dimensions of the channel of approach. The following table gives some of the results obtained for the coefficient c; the corresponding flows are calculated from the formula $Q = cH^{5/2}$, and the flows in gallons by taking 1 cub. ft. = 6·23 gallons:—

Head in Inches.	Value of c.	Flow in cub. ft./min.	Flow in Gallons/min.
2	0·3104	1·755	10·94
4	0·3047	9·750	60·74
6	0·3021	26·63	166·0
8	0·3006	54·06	338·9
10	0·2995	94·70	590·0

The above table applies to a narrow-surface notch, such as is frequently made by fixing narrow strips of brass to the up-stream side of the weir-board. The strips in this case were 8 in. broad and ⅛ in. thick. The edge of the notch was fully $\frac{1}{16}$ in. broad. A. W.

883. *Vibrations Proper to Molecules.* **E. Madelung.** (Gesell. Wiss. Göttingen, Nachr., Math.-Phys. Klasse, 1. pp. 43–58, 1910.)—This paper is supplementary to a previous one [see Abstract No. 1177 (1909)]. The author now succeeds in conceiving a model possessing the elastic and electric properties of the regular diatomic crystal. According to this model there is a relation between the elastic constants and the frequency of the infra-red proper molecular vibrations, which is approximately confirmed by observations. The model is not of quite definite structure, but rather there are a large number of similar models related to one another and differing by a numerical factor. The determination of this factor in a special case permits the calculation of the infra-red frequencies for other substances, which are in accord with observations, so far as they extend. E. H. B.

884. *The Principle of Relativity.* **D. F. Comstock.** (Science, 31. pp. 767–772, May 20, 1910.)—This article sets forth in a simple fashion the rudiments of the principle of relativity. This principle is one attempt, and by far the most successful one as yet, to explain the failure of all experiments designed to detect the earth's motion through space by its effect on terrestrial phenomena. It generalises this universal negative result into its *first postulate: The uniform translatory motion of any system cannot be detected by an observer travelling with the system and making observations on it alone.* The *second postulate* is: *The velocity of light is independent of the relative velocity of the source of light and observer.* The whole principle of relativity may be based on an answer to the question, When are two events which happen at some distance from each other to be considered simultaneous? The answer, "When they happen at the same time," only shifts the problem. The question is, How can we make two events happen at the same time when there is a considerable distance between them? Most people will agree that one of the best practical ways would be to send a signal to each point from a point half-way between them. The velocity with which signals travel through space is, of course, the characteristic "space velocity," or speed of light. Two clocks, one at A and the other at B, can therefore be set running in unison by means of a light signal sent to each from a place midway between them. Now suppose both the clocks at A and B are on a kind of pavement or platform moving uniformly with velocity v; just as on a fixed platform, since the observer on the moving platform is moving uniformly, he can have no reason to consider himself moving at all, and he will use the method just indicated to set his clocks A and B in unison. He will, that is, send a light flash from the mid-point C, and at the instants when these flashes reach A and B each clock will be started with the same reading. But to us on the fixed platform it is evident that the clock B, forward in space, is really a little behind the clock A in time. For, since the clocks are both moving at speed v, the light signal approaches A with speed $(V + v)$ and apppoaches B with speed $(V - v)$, where V is the speed of light. Hence if the distance $AB = l$, the times just mentioned are respectively $l/2(V + v)$ and $l/2(V - v)$. Thus the clock B is behind A by the difference of the above times, namely, $lv/(V^2 - v^2)$ or $l\beta/V(1 - \beta^2)$, where β is written for v/V. But it is important to see that the two clocks are in unison *for the observer moving with them* in the only sense in which the word unison has any meaning for him. For, on adoption of the first postulate of relativity, there is no way in which he can know that he is moving. In other words, he has just as much fundamental right to consider himself stationary as we have to consider ourselves stationary, and accordingly just as much right to apply the midway signal method to set his clocks in unison as we have in the setting of our clocks supposed stationary. "Stationary" is therefore a relative term, and anything which we can say about the moving system dependent on its motion can with absolutely equal right be said by the moving observer about our system. We are therefore forced to the conclusion that, unless we discard one of the two relativity postulates, the simultaneity of two distant events means a different thing to two different observers if they are moving with respect to each other.

The way in which this difference of opinion with regard to time between the moving observer and ourselves leads to a difference of opinion with regard to length also is then shown as follows. Suppose the moving observer desires to let us know the *distance* between his clocks at A and B, and says that he will have an assistant stationed at each clock, and each of these assistants, at a given instant, is to make a black line on our platform. He will thus be able to leave marked on our platform an exact measure of the length between his clocks; and let us compare it at leisure with any standard we choose. We, however, object to this measure left with us, on the ground that the two assistants did not make their marks simultaneously. Thus if M is the mark made on our platform for A and N for B, we say that the assistant at B made his mark too late, by waiting till his clock read the same time as A. So that on our view MN exceeds AB by the distance traversed by the moving platform in the time by which the moving clocks differ. This additional length is clearly $l\beta^2/(1-\beta^2)$, hence on our view the moving observer leaves us a record too long in the ratio $MN/AB = 1/(1-\beta^2)$. Again it must be emphasised that, because of the first postulate, there is no universal standard to be applied in settling such a difference of opinion. Neither the standpoint of the "moving" observer nor our standpoint is wrong. The two merely represent two different sides of reality. But it must be remembered that the results of the principle of relativity are no truer than its postulates. If future experience bears out these postulates, then the length of a body depends on the point of view, that is, on the relative motion of the observer and the object measured. Let us now ask, "What are corresponding lengths in the two systems?" The condition that two lengths should be corresponding is simply that each observer comes to the same conclusion with respect to the *other* length. The lengths AB and MN are not "corresponding." For the moving observer says they are equal, while we say that $AB/MN = 1-\beta^2$. Let us, however, mark off on our platform a length which is a mean proportional between our estimate of the length AB and the length MN. Then this length, ME say, will "correspond" to the length AB. For we shall say that $AB/ME = \sqrt{(1-\beta^2)}$, while the moving observer will say that $ME/AB = \sqrt{(1-\beta^2)}$, because his estimate of AB is MN. Thus, any length in the direction of motion on a moving system is estimated less in the ratio $\sqrt{(1-\beta^2)}$ by a "stationary" observer. Or, better, *an observer viewing a system which is moving with respect to him at a speed β times that of light sees all lengths, in the direction of motion, shrunk in the ratio $\sqrt{(1-\beta^2)}$.* Next examine the unit of time in each system. That in the moving system will appear greater than ours in the ratio $1/\sqrt{(1-\beta^2)}$. This is due to the fact that in the moving system forward clocks are behind in time. The moving observer can adopt as his unit of time the time it takes light, moving with speed V, to travel a distance $d/2$ and return. But we consider he is overestimating the distance d in the ratio $1/\sqrt{(1-\beta^2)}$. Further, on our reckoning he overestimates the average velocity with which his signal travels through his system in the ratio $1/(1-\beta^2)$. Because he calls it V both going and returning, while we call it $(V-v)$ one way, and $(V+v)$ the other. Thus on our reckoning the average velocity V_a is given by d/t where

$t = \frac{1}{2}d/(V - v) + \frac{1}{2}d/(V + v)$ or $V_a = V(1 - \beta^2)$. He is therefore underestimating his time in the ratio $\surd(1 - \beta^2)$. A certain time-interval, that is, appears less to him than to us, and hence his unit of time appears to us greater than ours in the ratio $1/\surd(1 - \beta^2)$. E. H. B.

885. *Terminal Speeds of Small Spheres in Air.* **J. Zeleny** and **L. W. McKeehan.** (Phys. Rev. 30. pp. 535–560, May, 1910.)—An experimental test of various small spherical bodies as to their agreement with Stokes' law for terminal velocity of fall, viz., $V = (2/9)ga^2(\sigma - \rho)/\mu$. The results for three kinds of spores are given in the table, c.g.s. units being used :—

Spores.	Radius.	Density.	$aV\rho/\mu$.	Observed Speed V′.	Calculated Speed V.	Ratio, V/V′.
Lycopodium…	0·00158	1·175	0·02	1·76	3·40	1·93
Polytrichum…	0·000478	1·53	0·0007	0·229	0·396	1·73
Lycoperdon…	0·000209	1·44	0·00007	0·0467	0·0718	1·52

Experiments were also made on artificial spheres (1) of black wax from 0·00366 to 0·00117 cm. in radius, (2) of mercury from 0·001075 to 0·000275 cm. in radius, and (3) of paraffin from 0·00415 to 0·00216 cm. in radius. In all these cases, when the spheres are of a size within the limits to which Stokes' formula applies, their velocities agree almost precisely with the theoretical values. E. H. B.

886. *Velocity of Bullets.* (Engineer, 109. p. 619, June 17, 1910.)—Describes an improved method, devised by Crantz, of measuring the velocity of a bullet by spark photography. The apparatus consists essentially of a horizontally pivoted revolving drum, covered with a photographic film, past which the bullet is fired. The bullet is illuminated as it passes the drum by a succession of electric sparks discharged at a given rate of 5000 per sec. The frequency of the spark and rate of revolution of the drum being known, the velocity of the bullet can be determined by measuring the distance apart of the images. This measurement is facilitated by interposing a glass rule divided into mm. between the spark and the drum; this, as well as the bullet, is photographed at each spark. To measure the reduction in velocity due to the resistance of the air or to passage through a plate two such drums are used, special arrangements being made for synchronising the drums and identifying the corresponding images of the bullet on each drum. The reduced distance apart of the images on the second drum gives the loss of velocity due to air-resistance, and the "lag" of the image on the second drum behind that on the first drum gives the time of flight over the distance between them. To keep the images clear a pendulum contact-breaker is used, which cuts off the current except during the small fraction of a second while the bullet is passing the drum. The same pendulum makes the electric contact which discharges the rifle. It is estimated that bullet velocities can be determined by this method with an error not exceeding ±0·8 m./sec. The principal use to which the apparatus is likely to be put is to determine the relative resistance of the air to bullets of different shapes. The ordinary Le Boulengé chronograph merely shows the time of flight between two

given points, and the result is affected by any variation in the muzzle velocity, as well as by the possible check experienced by the bullet in passing through the first chronograph screen. The Crantz instrument gives the actual velocity at each of two given points, as well as the time of flight between them. A. W.

887. *Influence of Surface Striation on Air-resistance.* **A. Lafay.** (Comptes Rendus, 150. pp. 1312–1314, May 23, 1910.)—When a current of air impinges upon a polished cylinder, a region on the surface thereof will be found, somewhat in advance of the transverse diam., at which the pressure of the air upon the surface is equal to that of the surrounding atmosphere; the pressure in front of this region being in excess, and that in the rear in defect, of the general atmospheric pressure. Over the region in question the rate of flow of the air current is greater than its mean velocity; the low pressure in the rear of this region is therefore the result of expansion [ejector action], and may be reduced by roughening the surface of the cylinder in this region of high velocity. Experiments demonstrating this are described, and tabulated results are given showing that in a horizontal air-current a cylinder having part of its surface suitably roughened with granulated cork was subject to a vertical thrust. It is suggested that propeller blades may be improved by an application of this principle. C. A. B.

888. *Viscosities of Gases of the Argon Group.* **A. O. Rankine.** (Roy. Soc., Proc. Ser. A. 83. pp. 516–525, April 14, 1910.)—The author has determined the viscosities of the rare gases by the method he has already described [Abstract No. 649 (1910)]. The absolute values of the viscosities in c.g.s. units on the basis of the author's absolute values for air [*loc. cit.*] are: Air (10·6°), 1·767; He (9·8°), 1·914; Ne (10·1°), 3·036; Ar (12·8°) 2·168; Kr (10·6°), 2·405; Xe (10·9°), 2·180; all multiplied by 10^{-4}. The numbers show neither a regular increase nor decrease of viscosity with atomic weight, but as the atomic weight increases, the viscosity increases and decreases in successive steps of gradually diminishing magnitude. The author does not assign a direct cause for this effect, but by applying the kinetic theory he deduces the relative mean free paths, molecular volumes, and atomic densities, and compares these values with the atomic weights and viscosities. As the atomic weight of the gas increases, the mean free path diminishes. On plotting the mean free path against atomic weight two lines are obtained, which intersect at a point close to the point representing the values for Argon. No explanation of this can be given. No simple relationship was found between atomic weight and molecular volume, although these magnitudes increase symbatically. A. F.

889. *Paths of Seismic Waves.* **E. Wiechert and L. Geiger.** (Phys. Zeitschr. 11. pp. 294–311, April 1, 1910.)—After a discussion of the importance of seismology in indicating the physical conditions of the earth's interior, the authors proceed to consider the paths of seismic radiations. Wiechert's indirect method is discussed at length, and some mathematical extensions are added. It is shown that in all probability there is no considerable change in the wave velocity on passing across the supposed boundary of the metal nucleus and rock crust. This, in the opinion of the authors, is no objection to their theory of the earth's interior, as although density and elasticity vary greatly in different substances under ordinary conditions, yet the velocity of elastic waves varies only slightly. The ratio of the velocities of the first and second phase waves alters little in the interior of the earth. From this the remarkable conclusion is drawn that the atoms themselves under the great pressure in the earth's interior behave somewhat like elastic spheres. The paper concludes with tables and curves showing the time of propagation, the surface velocity, and the angle of emergence for various paths. The velocities at different depths are also given, and compared with Oldham's determinations. A. D. R.

890. *Intrinsic Brightness of the Sun.* **C. Nordmann.** (Comptes Rendus, 150. pp. 881–882, March 29, 1910.)—In previous papers the author has outlined the method employed in determining the intrinsic brightness of the sun [see Abstract No. 521 (1910)]. He now draws attention to the values obtained by other workers using different methods, citing those of Müller (100,500 decimal candles per cm.^{2}), Fabry (184,000), and Pickering (352,000). The author's value (319,000) lies between the two latter determinations.

C. P. B.

891. *Spectrum of Daylight Comet,* 1910*a*. **H. F. Newall.** (Roy. Astronom. Soc., M.N. 70. pp. 459–461, March, 1910.)—The observations are only based on visual determinations, as it was found impossible to obtain any photographic record of the spectrum, partly on account of the low altitude of the comet and the constant dewing over of the object-glass of the equatorial. The records were made with a direct-vision spectroscope inserted between the eye and eyepiece; telescopes of 25 in. and 6¼ in. diam. were employed. On Jan. 22 it appeared that the main part of the luminosity of the envelope was due to sodium. Three images of the vertex were seen in the orange and red, but no sign of green or blue radiations. On Jan. 26 the spectrum of the nucleus exhibited the hydrocarbon bands red, yellow, green, and blue, quite well marked on a faint continuous spectrum. On Jan. 28 the sodium radiation was not seen beyond the nucleus. **W. Sidgreaves** and **A. L. Cortie.** (Ibid. pp. 464–465, March, 1910.)—A series of notes on the physical appearance of the comet from Jan. 25 to Feb. 4. On photographs taken on Jan. 26 with a 6-in. Dallmeyer portrait lens, exposures about 10 min., the tail was recorded to about 5° from the nucleus. The breadth of the tail near the nucleus was about 28′, and about 36′ at a distance of 4° 57′ from the nucleus. To the naked eye the nucleus was as bright as a first-magnitude star, the tail rising almost vertically from the horizon, with a slight convexity towards the sun. Examined with a direct-vision spectroscope the spectrum appeared to be continuous with a decided brightening in the green. C. P. B.

892. *Systematic Motions of the Stars shown in the Cross Proper Motions of the Bradley Stars.* **F. W. Dyson.** (Roy. Astronom. Soc., M.N. 70. pp. 416–429, March, 1910.)—In No. 9 of the Publications of the Groningen Laboratory Kapteyn gave the resolved parts of the proper motions of the Bradley stars in the direction of, and perpendicular to, that of the solar apex. Denoting the pole by P, the star by S, and the solar apex (RA. 18h. 12m., Dec. 29·5°) by A, the component motion along SA involves the solar motion, but the "cross" component perpendicular to SA does not. If the stars are arranged according to the azimuthal angle PAS, the corresponding cross proper motions may be arranged in groups for each 10°, say, of azimuth to which they are directed. If the peculiar motions of the stars have no preference for any direction these cross proper motions should show the same distribution for each group. But if a preference exists there should be a greater number of large proper motions in the neighbourhood of the favoured direction. Schwarzschild's "ellipsoidal" distribution is discussed by way of illustration. The author tabulates the cross proper motions of stars of Kapteyn's types I. and II. for every 10° interval of azimuthal angle (PAS). From an examination of the tables a systematic variation of the proper motion with the azimuth is deduced. The results are exhibited graphically, the points representing the mean annual cross proper motions being grouped, somewhat irregularly, about an ellipse, in the case of either star type. For stars of type II. the max. value is 4·46″ in azimuth −5°, and the minimum 1·84″ in the perpendicular direction. For stars of type I. the max. value is 2·88″ in azimuth −21°, and the minimum 1·14″ in the perpendicular direction. Taking the mean of these results, the azimuths of the directions in which the cross proper motions are greatest are −18° and −198, corresponding to the point (Q) R.A. +69°, Dec. +58°, and its opposite on the celestial sphere. The point Q is within 10° of the position required by Schwarzschild's hypothesis, whether Kapteyn's, Eddington's, Schwarzschild's, or Dyson's positions of the solar apex and stellar vertex be taken. Considering the difficulties, this accordance is as close as can be expected. The hypothesis that the proper motions of stars are greater in the direction of the Milky Way than in the perpendicular direction would agree equally well with the facts stated in the paper, for the plane of the cross motions is within 20° of perpendicularity to the plane of the Milky Way, and the point Q is 7¼° from the Milky Way. This examinaton of the resolved parts of proper motions at right angles to the direction of the solar motion is in agreement with Kapteyn's hypothesis of the existence of a vertex in the stellar motions, but does not exclude other hypotheses. The author himself draws attention to the fact that his method has the disadvantage of not eliminating the element of stellar distance, and is, moreover, limited to a consideration of motions in one plane. In previous investigations by Kapteyn and others the directions only of the stellar motions are used, and the question of distance does not enter. A. E.

REFERENCES.

893. *Polar Planimeter.* **E. Doležal.** (Akad. Wiss. Wien, Sitz. Ber. 118. 2a. pp. 1543–1574, Dec., 1909.)—Describes in detail and gives the mathematical theory of the Stampfer polar planimeter. The paper does not admit of a brief Abstract. Illustrations are given of the instrument, which is capable of giving accurate results and is easy to manipulate. A. W.

894. *Approximate Arithmetical Solution of Physical Problems involving Differential Equations.* **L. F. Richardson.** (Roy. Soc., Phil. Trans. 210. pp. 307–357, May 24, 1910.)—The object is to develop methods whereby the differential equations of physics may be applied more freely in the approximate form of difference equations to problems concerning irregular bodies. It is in purpose a continuation of a former paper by the author on a "Freehand Graphic Way of Determining Stream Lines and Equipotentials" [Abstract No. 458 (1908)].

895. *Lateral Deflection and Vibration of "Clamped-directed" Bars.* **J. Morrow.** (Phys. Soc., Proc. 21. pp. 500–514, Oct., 1909.)—[See Abstract No. 1857 (1909)].

896. *Comparison of Stream Discharges indicated by Current Meter and by Weir Formulas.* **J. C. Stevens.** (Eng. News, 63. pp. 481–482, April 28, 1910.)

LIGHT.

897. *Total Reflection.* **C. Schaefer and G. Gross.** (Ann. d. Physik, 32. 3. pp. 648–672, June 2, 1910.)—Deals with the disturbance in the second medium when total reflection is occurring at the interface, the treatment being electromagnetic. It is concluded that if, by any means, this disturbance in the second medium is changed in any way, or part of it absorbed, the reflection then ceases to be total. Experiments, in which the hypothenuse faces of prisms are closely approached, are described and shown to accord well with the theory. E. H. B.

898. *Havelock's Relation between Birefraction and Refractive Index.* **A. Cotton and H. Mouton.** (Comptes Rendus, 150. pp. 857–859, April 4, 1910.)—It was foreseen by Havelock [Abstracts Nos. 285 (1908), 658 (1909)] that the variation of the birefraction of a substance with the wave-length should be related simply to the variation of the index of refraction of the same medium in the isotropic state, the density being assumed to have the same value in the two cases. The relation at which he arrived can be written in the form, $n' - n'' = C(n^2 - 1)^2/n$, where n is the refractive index of the isotropic medium, C a constant, and n' and n'' are the principal indices of the uniaxial birefringent medium. The authors find that the magnetic birefraction of nitrobenzene obeys, at any rate very approximately, the law expressed by the above equation [compare McComb and Skinner, Abstract No. 54 (1910)]. The hypothesis by means of which Havelock was led to the above formula assumes that the molecules of the liquid are assimilable to isotropic substances, the arrangement of which is modified by the field. The authors show elsewhere that their hypothesis of the orientation of anisotropic molecules also leads to this same formula, but not to the relation, $n = (2n' + n'')/3$, established by Havelock. T. H. P.

899. *Birefringence of old Dialysed Iron; Study of Efflux of a Liquid into a Body of the same Liquid.* **L. Tieri.** (Accad. Lincei, Atti, 19. pp. 470–473, April 17, 1910.)—The value of the birefringence of a number of old specimens of dialysed iron—ranging from 10 to 28 years old—has been measured in terms of the velocity with which the liquid flows through a glass pipe, having a rectangular section of 2 mm. × 10 mm., and placed vertically in a bulk of the same liquid. The solutions have been also utilised for studying the efflux and influx of a liquid from and into a capillary tube immersed in a body of the same liquid, a glass vessel containing the dialysed iron, and with a pipette in its centre, being placed vertically between crossed nicols; and photographs are reproduced of the effects observed when (1) the principal sections of the nicols are at 45° with respect to the direction of flow of the liquid, and (2) one of the principal sections is parallel to the direction of flow. W. H. Si.

900. *Behaviour of Crystals in Light Parallel to an Optic Axis.* **C. Travis.** (Amer. Journ. Sci. 29. pp. 427–434, May, 1910.)—If a section of a biaxial crystal be cut normally to an optic axis, and examined in parallel light between crossed nicols, it appears uniformly bright in all positions when rotated about

the axis. This is commonly ascribed to interior conical refraction. Voigt has shown [Abstract No. 818 (1906)] that interior conical refraction has no practical existence; that what is observed is simply an approximation to it. The author's object is to give the correct explanation of the phenomenon. The effect produced by having a source of light at a finite distance from the section is considered. Light in the neighbourhoood of the optic axis forms no exception to the rule that an individual ray undergoes double refraction and traverses the crystal in two different rays, but the divergence of the two complementary rays is often a maximum near the optic axis. The conclusions arrived at are: (1) Interior conical refraction, in a strict sense, plays no part as a cause of the phenomenon. (2) The cause is to be found in the fact that so-called parallel light has commonly a considerable divergence. (3) In any given case, the observed intensity of illumination is equal to the average intensity of that portion of the interference figure bounded by the limits of the pencil of light used. The general configuration of the interference figure depends upon the optical constants of the crystal, and upon the thickness of the section; these, as well as the amount of divergence of the light, are the determining factors. (4) The reason why the same phenomenon is not commonly observed in uniaxial crystals is that in the uniaxial figure the first bright ring about the axis is in general much larger than that in the biaxial figure. Under proper conditions, however, the phenomenon may be also shown by a uniaxial crystal. A. E.

901. *Specific Refractive Powers, or Optical Constants of Substances in very Dilute Solutions.* **C. Chéneveau.** (Comptes Rendus, 150. pp. 866–869, April 4, 1910.)—The specific refractive power, $n - 1/d$ or $(n^2 - 1)/(n^2 + 2)d$, of a solution can be obtained directly, without determining the density, by measuring the refractive index by means of an interference refractometer. So that, knowing the refractive power of a solution, and assuming that the action of a solution on light is the sum of the actions of the dissolved substance and of the solvent occupying the same volume as the solution, the specific refractive power of the dissolved substance can be deduced. The results obtained on applying this method to very dilute solutions of KCl, NH_4NO_3, and $Mg(NO_3)_2$, show that the refractive power is virtually constant, excepting for very great dilutions where it varies very rapidly. This latter effect cannot be due to ionisation, and is, indeed, found to be caused by the fact that the temperature is not, in general, the same in the two cells of the refractometer. When steps are taken to ensure the equality of the temperatures in the two cells, it is found that ionisation does not appear to have any sensible influence on the refractive power of a dissolved substance when the concentration is greater than 0·5 gm. per litre. T. H. P.

902. *Simple Method of determining the Constants of a Lens or System of Lenses.* **P. af Bjerkén.** (Ark. för Mat. Astron. och Fysik, Stockholm, 6. 7. pp. 1–5, 1910.)—The method avoids the difficulty of setting cross-wires precisely on the image of an infinitely distant object, and also avoids any necessity for touching the lens with an instrument, at the risk of injury, in measuring the thickness. An object at finite distance is employed, consisting of cross-wires, or a mark on an extremely thin transparent plate. Lens and object are mounted on an optical bench about 8 m. long, with a very exact millimetre metal scale attached. On the bench slides a microscope of moderate power, with an objective of focus about 81 mm., and carrying on either side a vernier enabling distances down to 0·1 mm. to be measured.

The microscope is first placed on the image side of the lens beyond the image, and pointing along the optic axis towards image and lens. It is adjusted in the optic axis by bringing the object and image into coincidence in the field of view. The microscope is then focussed in turn upon the image, the rear face, and the front face (or rather the image of the front face) of the lens, and the distances it has to be shifted between the operations are read off on the scale. These measured shifts are equal to the distances between the image and lens faces. Next, the microscope, still pointing in the same direction, is focussed upon the object—a step which necessitates lifting the microscope over the lens. Comparison of the new scale-reading with the last gives the distance of the object from one face of the lens. The microscope is then reversed, placed on the side of the object away from the lens, and focussed in turn upon the object and two faces of the lens, the shifts between the operations being measured as before. By a simple process of addition and subtraction, the thickness of the lens, and the distances of object and image from its faces, are obtained. The principal lens-constants can thence be deduced by means of well-known formulæ. The method can be adapted to a concave lens. A. E.

903. *Sensitiveness of the Eye.* **R. v. Koch.** (Phys. Zeitschr. 11. pp. 238–240, March 15, 1910.)—Many researches, some theoretical, some experimental, have been undertaken with regard to the sensitiveness of the eye for the different colours of the spectrum [see Abstract No. 1922 (1905)], but little is known as to the effect on the eye of a single colour of varying intensity, or of the total light radiation of a beam. The problem which is here discussed may be stated thus: If a white surface receives an equal quantity of light energy per sec. per unit area, the light being composed of different radiations, how great is in each case the photometric brightness of the surface? Bolometric and photometric measurements were made at a distance of 70 cm. from several different types of lamp, and it was found that for a carbon filament lamp the light intensity for different temperatures is proportional to the 8·7th power of the current through the lamp. So the sensation of light which the eye receives from a surface which is illuminated by an incandescent lamp varies according to the 1·85th power of the quantity of energy per sec. given out by the surface if the temperature of the filament of the lamp is altered. A. W.

904. *Radiation through Three-colour Filters.* **G. Leimbach.** (Phys. Zeitschr. 11. pp. 313–316, April 15, 1910.)—The author discusses certain discrepancies between his own data [Abstract No. 1209 (1909)] and those of Precht and Stenger [Abstract No. 1561 (1905)], and attributes these to the concomitant effects of heat-rays which accompany the selected colour wavelengths transmitted through the filters. He attributes a part of the effect of ordinary white light to heat-rays, and finds that Hefner lamplight acts upon silver bromide about equally with green light of the same energy value. All wave-lengths follow the same law as to the relative exposures required to produce a given gradient of deposit of silver. A. D.

905. *The Doppler-effect with Canal Rays in Hydrogen.* **B. Strasser.** (Ann. d. Physik, 31. 5. pp. 890–918, April 5, 1910.)—Through the Doppler-effect there is an intensity minimum between the "resting" and the moving line [see Abstract No. 57 (1907)], the resting line being due to luminous

particles possessing only an insignificant velocity. The intensity of the resting and the moving line in the Doppler-effect of the canal rays in hydrogen is dependent upon the purity of the gas. The purer the hydrogen the more does the resting line go back to the moving line, so that with very pure gas only the moving line is observable. The intensity of the resting line increases with the addition of definite masses of another diluting gas, whilst the intensity of the moving line decreases. With very great impurity of the hydrogen the intensity minimum is no longer noticeable: the moving line joins on directly to the resting one. Gases of great atomic weight added to the hydrogen exert with equal volumes a stronger action on the distribution of intensity of the resting and moving lines than gases of small atomic weight. Metallic particles, due to disintegration of the electrodes, have an effect on the appearance of the Doppler-effect similar to that caused by mixed gas. In the spectrum of the canal rays the lines of hydrogen and of the mixed gas are observed directly behind the kathode. In the further course of the canal rays the lines of the mixed gas recede more and more towards the hydrogen lines, so that at a distance of 25 cm. from the kathode the hydrogen spectrum is almost the only one visible. The change of velocity of the canal rays produced by an electric field can be proved by the observation of the Doppler-effect of the spectral lines. For the specific charge e/m of the hydrogen canal rays, ascertained from the magnitude of the change of velocity, the upper limiting value $e/m = 10^4$ was established. At the commencement of the first kathode layer only one velocity of the canal rays exists; with approach to the kathode even greater velocities appear. The Doppler band in the first kathode layer is considerably weaker than in the light behind the kathode. J. J. S.

906. *Relation between Absorption Spectra and Chemical Constitution.* Part XIV. *Aromatic Compounds and the Quinonoid Theory.* **E. C. C. Baly, W. B. Tuck, and E. G. Marsden.** (Chem. Soc., Journ. 97. pp. 571–598, March, 1910.)—Further experimental support is given to the thesis that the nitrogroup restrains (as shown by an examination of the absorption spectrum) the vibrations of the benzene ring. The restraint due to nitrogroups may be counteracted by other groups. It is suggested by the authors that isorropesis (based on the play of forces between the residual affinities in the various intramolecular groups) gives a better explanation than does quinonoid structure, of the colour and absorptivity of the nitrophenols and nitroanilines.

D. H. J.

907. *Prolongation of the Band Spectrum of Nitrogen into the Red and Infrared.* **F. Croze.** (Comptes Rendus, 150. pp. 860–863, April 4, 1910.)—By photographing the spectrum of nitrogen with a prism instrument the author has succeeded in measuring new bands in the red and commencement of the infra-red regions. Two new sub-groups have been recognised, one with ten bands, and the other (less refrangible) with six. The first group of nitrogen contains between $\lambda = 9100$ and $\lambda = 5000$ six sub-groups which are quite comparable. The laws of Deslandres apply to the new sub-groups with considerable accuracy. E. C. C. B.

908. *Effect of Pressure upon Arc Spectra—Titanium.* **R. Rossi.** (Roy. Soc., Proc. Ser. A. 83. pp. 414–420, March 22, 1910.)—The apparatus used was the same as that described by Duffield [see Abstracts Nos. 780 (1908) and 284 (1909)] and the arc was struck between two cylindrical poles. The upper one (negative) was carbon, and the lower one was a graphite tube filled with powdered titanium carbide. The pressures employed were 15, 30, 50, and 100 atmos. above ordinary pressure, and 52 lines between the limits $\lambda = 4594$ and $\lambda = 4025$ were examined. The pressure displacements of the unreversed lines vary greatly from line to line and no grouping seems possible. The pressure displacements of the reversed lines fall into two groups, the mean displacements of which are nearly in the ratio of 3 : 5. The mean displacement of all the lines is 0·00865 Å.U. per atmo. No relation could be found between displacement and Zeeman-effect. Most of the lines are relatively enhanced or weakened by pressure, and with one exception all the lines which are weakened in passing from the arc to the furnace, are strengthened by pressure in the arc [see Abstract No. 1414 (1908)]. E. C. C. B.

909. *Absorption and Reversal Phenomena with Hydrogen.* **A. Pflüger.** (Deutsch. Phys. Gesell., Verh. 12. 5. pp. 208–214, March 15, 1910.)—The author in a previous paper showed that the hydrogen lines could readily be obtained reversed, and the work was repeated and confirmed by Ladenburg, who, however, said that the results obtained afforded a clear proof that Kirchhoff's law is not obeyed and that, therefore, the radiations of luminescent hydrogen are not temperature radiations. The author now proves that Ladenburg was wrong in his deductions, and that the whole of the phenomena observed can be explained on the basis of the Kirchhoff relation $E/A = \epsilon$, where E is the emission, A the absorption of the gas, and ϵ the emission of the black body. He moreover shows that the various types of reversal, *e.g.*, double reversal, can be readily explained. E. C. C. B.

910. *Absorption Spectra of the Vapours of the Alkali Metals.* **P. V. Bevan.** (Roy. Soc., Proc. Ser. A. 83. pp. 421–428, March 22, 1910.)—Observations of the absorption spectra of K, Rb, and Cs, 24, 25, and 21 lines respectively being measured in the principal series. The author finds that neither Kayser and Runge's, nor Rydberg's, nor Ritz's formula gives satisfactory results when applied to the oscillation-frequencies of the lines. Attempts were made to observe the absorption spectrum of Li, but a sufficient density of the vapour could not be obtained. E. C. C. B.

911. *Magnetic Separation of Absorption Lines.* **P. Zeeman** and **B. Winawer.** (Konink. Akad. Wetensch. Amsterdam, Proc. 12. pp. 584–596, March 24, 1910.)—The dark lines which appear in a continuous spectrum, if a beam of light traverses an absorbing flame, are divided and polarised under the influence of magnetic forces in exactly the same way as emission lines. This inverse effect has become of considerable importance since the discovery of Hale that sun-spots are the centres of intense magnetic fields, and that the dark lines in the absorption spectra of sun-spots exhibit the characteristic phenomena of magnetic separation. In the present communication the authors describe the results of an investigation of the separation of the absorption sodium lines D_1D_2 under various types of magnetic field, these lines exhibiting changes of very similar type to those observed in sun-spot spectra. If the observations are made perpendicular to the field, we see in the continuous spectrum 4 dark components in the case of D_1, and 6 dark components in the case of D_2. Their relative visibility is to some extent dependent on the vapour density of the absorbing medium. They may be made to appear sharper and blacker by interposing a quarter-wave plate and a nicol into the path of the beam. Many of the results were photographed with a Rowland grating spectrograph, and several of these are reproduced with the paper, illustrating the very close imitation of typical spot lines.

C. P. B.

912. *Origin of Anomalies recently observed in the Zeeman-effect.* **O. M. Corbino.** (Accad. Lincei, Atti, 19. pp. 466–470, April 17, 1910.)—The apparent anomalies observed by Nagaoka [Abstract No. 1882 (1909)] and by Tenani [Abstract No. 682 (1910)] are attributed to the non-uniformity of the magnetic field employed—a method specially devised by the author, showing that for an ordinary field, while the variation in intensity in a direction normal to the field is almost inappreciable, the variation in the plane of the field is very considerable and quite sufficient to account for the unusual results obtained. The method consists in placing a small glass vessel containing Bravais' iron solution between the poles of the electromagnet, and also between crossed nicols at an angle of 45° to the direction of the field, and then examining with a direct-vision spectroscope a beam of transmitted sunlight.

W. H. St.

913. *Zeeman-effect of the Yellow Mercury Line* $\lambda = 5770$. **H. Nagaoka.** (Nature, 83. pp. 276–277, May 5, 1910.)—Using a special vacuum tube the author finds that the Hg line $\lambda = 5770$ is resolved into a nonet, for which Runge's law is obeyed. The differences in the vibrations of the lines can be expressed by—

$$0, \pm\frac{a}{8}, \pm\frac{8}{8}a, \pm\frac{9}{8}a, \pm\frac{10}{8}a$$

where $a = e/m \,.\, H4/\pi$. From the measurements e/m is found to be $1{\cdot}88 \times 10^7$, which equals the value of $1{\cdot}80 \times 10^7$ found for $\lambda = 5461$. Three different classes of nonets may be derived from the normal triplet, namely—

$$(1)\ 0, \pm\frac{a}{8}, \pm\frac{8}{8}a, \pm\frac{9}{8}a, \pm\frac{10}{8}a,$$

$$(2)\ 0, \pm\frac{a}{4}, \pm\frac{4}{4}a, \pm\frac{5}{4}a, \pm\frac{6}{4}a,$$

$$(3)\ 0, \pm\frac{a}{2}, \pm\frac{2}{2}a, \pm\frac{3}{2}a, \pm\frac{4}{2}a.$$

(1) is represented by Hg $\lambda = 5770$, (2) by Ne $\lambda\lambda = 6678$ and 6805, and (3) by Hg $\lambda = 5461$. Possibly there is a fourth type—

$$0, \pm\frac{a}{16}, \pm\frac{16}{16}a, \pm\frac{17}{16}a, \pm\frac{18}{16}a,$$

and Cu $\lambda = 5105$ seems to belong to this type, but higher resolving power is required to decide the point. It would appear that triplets which show broadening of the lines and no asymmetry in high fields, and give values of e/m greater than $1{\cdot}87 \times 10^7$, belong to some of the intermediary types.

E. C. C. B.

914. *Studies in Luminescence. Distribution of Energy in Fluorescence Spectra.* **E. L. Nichols and E. Merritt.** (Phys. Rev. 30. pp. 328–346, March, 1910.)—A measurement of the fluorescence energy curves of eosin, fluorescein, and resorufin. The fluorescence was excited by the rays from a Cooper-Hewitt

mercury lamp, and corrections were introduced for slit-width and for absorption; the corrected energy curves are given in the paper. They suggest by their form a close resemblance between black-body radiation and fluorescence, except that the range of wave-lengths in the latter case is much smaller. Attempts to find a simple modified form of Wien's equation to represent the results, have failed up to the present. E. C. C. B.

915. *Polarisation of Röntgen Rays.* **L. Vegard.** (Roy. Soc., Proc. Ser. A. 83. pp. 379–393, March 22, 1910.)—An account is given of an investigation on polarisation of primary X-rays compared with their power of exciting high-velocity kathode rays. An ionisation method was adopted in the experiments. The existence of polarisation in the primary radiation was confirmed. The part which is polarised possesses at the same time a great power of exciting high-velocity kathode rays, which shows that the polarised and unpolarised part in this respect are essentially of the same type. The efficiency of producing high-velocity kathode rays is even somewhat greater for the polarised than for the unpolarised part of the beam. Screening the beam before striking the radiator slightly increased the polarisation. It had no observable effect on the efficiency of the polarised part to produce kathode rays, while that of the unpolarised was increased. The angle of incidence of the kathode rays, when other conditions were the same, had a very small but still noticeable effect on the polarisation, the latter being greater for a greater angle. Thus the polarisation cannot be accounted for by any singular distribution of intensity across the primary beam. J. J. S.

916. *Organic Compounds which exhibit Spontaneous Oxidation with Phosphorescence.* **M. Delépine.** (Comptes Rendus, 150. pp. 876–878, April 4, 1910.)—Spontaneous oxidation, accompanied by phosphorescence, is exhibited by (1) thiosulphocarbonic esters, $OR'.CS.SR^2$; and (2) sulphocarbamic esters, $NR'_2.CS.OR^2$, to all of which the grouping $.CS.O.$ is common. One of the conditions of this phosphorescence appears to be the presence of a considerable excess of oxygen. T. H. P.

917. *Radio-activity of Potassium.* **J. Elster** and **H. Geitel.** (Phys. Zeitschr. 11. pp. 275–280, April 1, 1910. From the 16. Jahresberichte des Vereins f. Naturwiss., Braunschweig, 1908–1909.)—The authors show that potassium salts exhibit a slight radio-activity, thus confirming the results obtained by other investigators. With the object of separating off a more active substance which might possibly occur in potassium, different salts were subjected to chemical processes or treated as solutions by electrolysis. All these experiments, however, led to negative results, showing that the activity of potassium must be ascribed to the metal itself. Special experiments were also made to find whether any emanation is given off from potassium salts. These experiments also led to negative results. E. M.

918. *Phosphorescence of Uranyl Salts at very Low Temperatures.* **H.** and **J. Becquerel** and **H. Kamerlingh Onnes.** (Comptes Rendus, 150. pp. 647–652, March 14, 1910. Annal. Chim. Phys. 20. pp. 145–165, June, 1910.)—When the temperature is lowered to the solidifying point of hydrogen the phosphorescence bands of uranyl salts become increasingly narrow [compare Abstract No. 884 (1907)], the maxima of emission being displaced towards the small wave-lengths. Between the ordinary temperature and 80° K the displacements amount to 2–8 $\mu\mu$, and between 80° K and 20° K (liquid hydrogen) to 0·18–0·26 $\mu\mu$; between 20° K

and 14° K the displacements are scarcely perceptible, and as the temperature is lowered the position of the bands seems to approach asymptotically a limiting position. This change is of the same nature as the change of volume and, probably, the change of the dielectric constant. The phosphorescence spectrum of a uranyl salt is composed of seven or eight groups occurring at intervals, their aspects being, if not identical, only slightly different; the more refrangible groups alone often differ in appearance from the others. The name "homologous band" is given to those occupying the same relative positions in the different groups. The different aspects of the different groups are found to depend only on progressive changes in the relative intensities of the bands. All uranyl salts containing one and the same acid and different bases united with the uranyl group give spectra having the same general aspect, so that the constitution of the spectrum depends principally on the nature of the acid of the salt, and is only slightly influenced by the bases. Between two consecutive homologous bands the difference of the frequencies is sensibly constant, not only for any one series, but for all the series of homologous bands of one and the same salt; further, the constant expressing the difference of frequency between two consecutive homologous bands varies only slightly from one salt to another. In a magnetic field exceeding 20,000 gauss no appreciable action is exerted on the bands at 14° K. Certain of the bands in the two most refrangible groups of the emission spectrum are, like the sodium lines, reversible, being transformable into emission bands; it is to these reversible bands that the marked differences between the more and less refrangible groups are mainly due. Uranyl salts form a separate class among phosphorescent substances, since their phosphorescence spectra are due to the uranium itself and not to the presence of a small proportion of a phosphorogen. It seems probable that, with uranyl salts, the luminous centres producing phosphorescence bands are very few in comparison with the total number of the molecules. T. H. P.

919. *Effect of Temperature on Fluorescence and Absorption.* II. *Fluorescence and Absorption of Canary Glass at Low Temperatures.* **R. C. Gibbs.** (Phys. Rev. 30. pp. 377–384, March, 1910.)—An extension of the previous investigation to low temperatures [see Abstract No. 554 (1910)]. It was found that the fluorescence band was apparently made up of two closely situated and overlapping bands, and it is now found that, on cooling, the main portion of the band increases very decidedly and breaks up into two bands which are very close together. A decrease in the absorption also occurs, together with a corresponding narrowing of the absorption band. At the extreme low temperatures (−175° C.) the fluorescence intensity decreases on the side of the shorter wave-lengths, thus narrowing the band on that side. The fluorescence bands which develop on cooling appear to be the same ones which were practically destroyed at the higher temperatures, and the band which existed at the higher temperatures is destroyed by cooling, or else did not exist at ordinary temperatures. The lag in recovery after exposure to heat may extend over a considerable period of time. E. C. C. B.

920. *Behaviour of Particles from Radium A in an Electric Field.* **J. Salpeter.** (Acad. Sci. Cracovie, Bull. 1a. pp. 23–32, Jan., and 2a. pp. 33–37, Feb., 1910.)—Schmidt has previously described a method for making a direct comparison of the coefficients of mobility and recombination of the RaA atoms with the corresponding constants of the ions in air [see Abstract No. 842 (1908)]. They were found to be of the same order of magnitude. The existence of a marked difference in the behaviour of RaA atoms and ions was, however, suggested by the fact that a relatively large amount of RaA was obtained on an uncharged electrode. The author believes that the explanation suggested by Schmidt can only partially account for the experimental results, and gives a theoretical treatment of the problem, taking into consideration not only the mobility and recombination of the RaA atoms, but also their diffusion. The problem treated is the following: Radium emanation producing RaA at a constant rate is distributed uniformly between two parallel plates. The amount of RaA deposited on each of the plates is determined as a function of the density of the emanation, the distance apart of the plates and their p.d., and the above-mentioned constants of the RaA atoms. E. M.

921. *Measurement of Radium by its Emanation.* **Mme. P. Curie.** (Le Radium, 7. pp. 65–70, March, 1910.)—A detailed description of experiments on the comparison of the amounts of Ra in different solutions by means of the emanation accumulated in a known time. The solution containing Ra is placed in a closed "bubbler" and the emanation allowed to accumulate. Air is then bubbled through and, along with the emanation carried with it, passed into an ionisation chamber, where measurements of its activity are made. After suitable corrections these are compared with the measurements of the activity due to the emanation from a standard solution of Ra in a similar apparatus. It was found that with due precautions measurements could be made by this method with an accuracy of 0·5 per cent. The max. current from an amount of emanation equivalent to 1 gm. Ra was calculated to be $8{\cdot}5 \times 10^5$ e.s. units, the chamber being 12 cm. high and 6·7 cm. in internal diam. E. M.

922. *Photographic Action of the α-Particles.* **S. Kinoshita.** (Roy. Soc., Proc. Ser. A. 83. pp. 432–453, March 22, 1910.)—A detailed investigation of the effect of α-particles on a sensitive film, in regard to the amount of silver halide altered under the influence of the particles and thus rendered capable of development. Measurements were made, firstly of the photometric density of the film, and secondly, by means of a high-power microscope, of the actual number of halide grains produced in the film on complete development. As source of α-particles RaC was used, while for the films Wratten's "Instantaneous" and "Ordinary" emulsions thinly coated on patent plate glass were employed. It was found that the photographic action of the α-particles is constant over their path and therefore does not vary with the ionisation, which is known to increase rapidly towards the end of the range. The experimental facts show that if some of the halide molecules within a grain are initially ionised by an α-particle, the whole grain becomes capable of development, but the reduction cannot extend to other grains which have not been ionised. It is hoped, by preparing a suitable emulsion film, and by using a microscope of high magnification, that the photographic method can be applied for counting α-particles with considerable accuracy. E. M.

923. *Course of Radio-active Projections.* **L. Wertenstein.** (Comptes Rendus, 150. pp. 869–872, April 4, 1910.)—It is known that the α-particles are propagated in a practically straight line to the point where they stop, the path being well defined for each kind of α-particles. The author has investigated the case of the projection of RaB by RaA in order to ascertain whether the projection exhibits a character analogous to the above. Debierne (Le Radium, March, 1909) has shown that the path, if there is one, is certainly less than 1 mm. at atmospheric pressure. The author's results show that the

RaB particles traverse a definite path equal to 2 mm. at 45 mm. pressure, and that the length of this path is inversely proportional to the pressure, the product of path and pressure being about 90. At the normal pressure the path is about 0·1 mm., corresponding with a penetrability 400 times less than that of the α-rays of RaA, so that gold-leaf 0·08 μ in thickness would arrest the particles completely. T. H. P.

924. *Radio-active Recoil.* **S. Russ.** (Manchester Lit. and Phil. Soc., Mem. 54. 2. pp. 1–12, 1909–1910.)—In previous experiments of Makower and Russ [Abstract No. 1068 (1909)] it was shown that when RaEm is condensed at the bottom of a tube and the space above it is evacuated, particles of active deposit are radiated up the tube, this phenomenon being due to the recoil of the atom when an α-particle is emitted from it. These atoms of active deposit can be collected on a disc, and the object of the present investigation has been to find the relative numbers of RaA, RaB, and RaC particles radiated away from the condensed emanation, by an analysis of the decay curves of the active deposit collected on the aforesaid disc for different times of exposure. The results of the investigation show that RaA and RaB particles are projected in about equal proportions from emanation which has attained equilibrium with its products as far as RaC, while in comparison the number of RaC particles which recoil as the result of the ejection of β-particles from RaB, is small. E. M.

925. *Radium Distribution.* **J. Salpeter.** (Akad. Wiss. Wien, Sitz. Ber. 118. 2a. pp. 1197–1205, Oct., 1909.)—An indirect method of Kohlrausch and Kurz for measuring the RaEm-content of the atmosphere depends on the assumption that the density of the radium induction is proportional to that of the radium emanation present. In the present paper the author discusses the effect of the earth's field on the distribution of radium induction in the atmosphere and on the earth's surface. He finds that the density of RaA in the atmosphere may vary under the influence of the earth's field by as much as 20 per cent. The same holds for RaB and RaC. It is also shown that with increasing potential-fall the surface density of the radio-active deposit on the earth also increases. A. W.

926. *Measurement of Radium Emanation.* **W. Duane and A. Laborde.** (Comptes Rendus, 150. pp. 1421–1423, May 30, 1910.)—In a previous paper [see Abstract No. 1217 (1905)] Duane has given a relation between the ionisation produced by radium emanation inside a cylindrical ionisation chamber with a central electrode, the dimensions of the chamber, and the amount of emanation contained in it. The present paper contains a determination of the various constants in the relation, using for the purpose the standard solutions of Mme. Curie. The following are the relations:—

$$x = I_0/5{\cdot}19(1 - 0{\cdot}517S/V) = I_{max.}/18{\cdot}15(1 - 0{\cdot}572S/V).$$

x is the amount of RaEm expressed in terms of the amount produced per sec. from 1 gm. Ra; S and V are the internal area and volume respectively of the ionisation chamber; I_0 and $I_{max.}$ are the initial and max. ionisation currents produced in the chamber, these currents being measured in electrostatic units at atmospheric pressure and about 15° C., and the max. current being produced about 3 hours after the introduction of the emanation. The authors find that the formulæ hold for different ionisation chambers with a wide range of dimensions, but chambers whose lengths were about twice the diam. were generally used. [Compare also Abstract No. 921 (1910).] E. M.

927. *Secondary Radiation excited by Uranium X.* **W. B. Huff.** (Phys. Rev. 30. pp. 482–491, April, 1910.)—The experimental results of this research lead to the conclusion that the direct method of comparing the secondary radiations here adopted are in agreement with Schmidt's statement that the intensities of secondary radiation excited by β-rays of UrX are in the order of atomic weights for elementary substances. Although the order seems definite, the total ionisation effects vary greatly with the arrangement of apparatus. The reflection and absorption seem not to follow any simple law. The curves bring out clearly characteristic differences for three typical elements (Pb, Sn, and Al) when acting as reflectors and as absorbers. Nothing in the nature of selective absorption was detected. This may be held to indicate that the secondary is largely returned or scattered primary, rather than independent, though characteristic, radiation emitted merely as a result of incident primary. [See Abstracts Nos. 1826 and 1881 (1907).] E. H. B.

928. *Long-period Determination of the Rate of Production of Helium from Radium.* **J. Dewar.** (Roy. Soc., Proc. Ser. A. 83. pp. 404–408, March 22, 1910.)—In a previous research [see Abstract No. 1808 (1908)] the rate of the production of helium from 70 mgm. of radium chloride was determined by a succession of observations on the growth of pressure measured by a McLeod gauge, the observations extending over 6 weeks. It was thought desirable to make an experiment to determine the amount of He resulting from this same sample of radium, after standing in a sealed bulb for an extended period. For this purpose the bulb containing the radium chloride was sealed off at the conclusion of the above-mentioned experiment of 1908 and kept for 9 months. In order to measure the He thus produced it was necessary to devise a vacuum-tight joint between the sealed radium bulb and a McLeod gauge so constructed that, after thoroughly exhausting the gauge, the drawn-out end of the radium bulb could be broken off, thus allowing the pressure of the accumulated He in the radium bulb to be rapidly determined. This is described by aid of a figure. The capillary sealed-up part of the bulb had a file mark on it and could be rocked from the outside so as to be snapped off by pressure against a neighbouring protuberance. The data of the experiment show that a corrected pressure of 0·01618 mm. in a volume of 820 cm.^{3} was due to the He produced from 70 mgm. of pure radium chloride during a period of 275 days. It is hence deduced that the rate of production of He is 0·468 mm.^{3} per gm. of Ra per day. In the 1908 paper the rate of production was given as 0·37, but on again examining the apparatus it was discovered that the volume of that gauge and apparatus then used was 270 cm.^{3}, and not 200 cm.^{3} as formerly supposed. The previous value is thus corrected to 0·499 mm.^{3} of helium per gm. of Ra per day, which is in good agreement with the present determination. Indeed, the author thinks the true value may lie between these two results 0·468 and 0·499. E. H. B.

929. *Decay Products of Radium and Thorium in the Atmosphere.* **D. Pacini.** (Phys. Zeitschr. 11. pp. 227–232, March 15, 1910. N. Cimento, 19. pp. 845–357, May, 1910.)—A negatively electrified wire set up in the open air receives a radio-active deposit consisting chiefly of the decay

products of Ra and Th emanations. Bumstead [Abstract No. 2560 (1904)], who exposed wires for 12 hours at New Haven, found that 15 per cent. of the total activity was due to Th, while Blanc [Abstract No. 2049 (1907)], with exposures of 8 days at Rome, found the percentage to be 75. Further, Harvey has found that the direction of the wind and other meteorological conditions have important effects upon the results obtained. As the result of the present observations carried out at Sestola, in the Apennines, at an altitude of 1090 m., it is concluded that the mean value of the ratio N′/N (*i.e.*, ratio of the Ra and Th emanations present in 1 m.^{3} of air) during the summer of 1909 was 6700. Gentle breezes from the valley or plain accompanied by a rise in the barometer cause a rise in N′/N; with a diminution of the air pressure and stronger breezes, but still from the lower grounds, the ratio N′/N diminishes. A considerable alteration of the velocity of the wind coming from the same direction seems to have more influence upon N′/N than an alteration of the air-pressure. The influence of the wind seems to depend mainly upon its direction, the wind coming from the higher peaks of the Apennines increasing the amount of Ra decay product present in the air, while the winds from the valleys and plains bring Th products. The time in which the initial activity falls to half-value fluctuates between 52 and 85 min. The smallest percentage of Th present was 29, and the highest 78.
A. E. G.

930. *Table of the Radio-active Elements.* **H. Greinacher.** (Zeitschr. Elektrochem. 16. pp. 267–269, April 15, 1910.)—The author gives a table showing the constants of all the radio-active elements which have been described and of the various kinds of radiation they emit. According to the view held at the present time, an individual substance only emits rays of one kind, these rays being homogeneous, that is, of one and the same penetrability. Two of the elements, namely, radium and radio-actinium, do not fall into line with this view; so that there exists the possibility of, on the one hand, RaX and, on the other, a meso-actinium being present. The uranium family also probably contains another element situate between UrX and ionium. A method of isolating the radio-active elements is indicated.
T. H. P.

REFERENCES.

931. *New Petrographic Microscope and New Ocular for Use with Same.* **F. E. Wright.** (Amer. Journ. Sci. 29. pp. 407–426, May, 1910.)

932. *Anastigmats composed of Three Cemented Lenses.* **O. Heimstädt.** (Zeitschr. wiss. Phot. 8. pp. 101–110, Jan., 1910. From the Optical Works of C. Reichert, Vienna.)

933. *Graphic Method of dealing with Combinations of Co-axial Refracting Surfaces.* **H. S. Allen.** (Phys. Soc., Proc. 21. pp. 480–483; Discussion, pp. 483–484, Oct., 1909. Abstract.)

934. *Photographic Screen Plates.* **C. E. K. Mees** and **J. H. Pledge.** (Photographic Journ. 50. pp. 197–219; Discussion, pp. 219–221, May, 1910.)—A very thorough comparative analysis of the mode of production and properties of screen plates for colour photography, and of the conditions which are necessary for success.
A. D.

935. *Colour-blindness and the Trichromatic Theory of Colour-vision.* **W. de W. Abney.** (Roy. Soc., Proc. Ser. A. 83. pp. 462–478, April 14, 1910.)

936. *The Photographic Plate.* II. *The Emulsion.* **W. D. Bancroft.** (Journ. Phys. Chem. 14. pp. 97–151, Feb., and pp. 201–259, March, 1910.)—An outline of our knowledge in respect to the effect on sensitiveness of opacity, of coarseness of the grain, of concentration of water and gelatine during the precipitation of silver bromide, and of concentration of water in the finished plate. A full discussion is given of the theory of chemical sensitisers; of the effects of various media used for the emulsion (gelatine, collodion, colloid silicic acid, agar-agar, &c.); changes during ripening in the relative sensitiveness to light of different wave-lengths, with and without development; sensitising plates; effect of the medium in retarding the action of the developer on the unexposed silver bromide; sensitiveness of precipitated silver bromide to development; the ultra-violet plate. A working hypothesis as to the emulsion to be presented in a further communication. A. D.

937. *The Lessons of Radio-activity.* **W. H. Bragg.** (Chem. News, 101. pp. 101–103, March 4; 111–113, March 11; 134–137, March 24, and pp. 148–149, April 1, 1910. Extract from Inaug. Address to the Australian Assoc. for Advancement of Science, 1909.)

938. *Experimental Determination of the Nature of the γ-Rays.* **E. v. Schweidler.** (Phys. Zeitschr. 11. pp. 225–227, March 15, 1910.)—This is in the main a preliminary communication dealing with (*a*) the theoretical investigation as to the method of tackling the problem, and (*b*) the experimental methods by which it is possible to obtain the information desired. The experimental determination is in progress. A. E. G.

939. *Analysis of Principal Mercury Lines.* **H. G. Gale** and **H. B. Lemon.** (Astrophys. Journ. 31. pp. 78–87, Jan., 1910. Phys. Zeitschr. 11. pp. 209–215, March 15, 1910.)—The authors give the results obtained with a Littrow grating spectroscope, having a lens 20 ft. focal length and a grating 6½ in. by 2¼ in. Using the light from a mercury vapour lamp, the satellites of the lines were successfully photographed, and the results agree very closely with those originally published by Michelson. C. P. B.

HEAT.

940. *Influence of Pressure on the Boiling-points of Metals.* **H. C. Greenwood.** (Roy. Soc., Proc. Ser. A. 83. pp. 483–491, April 14, 1910.)—Describes the methods of determining the boiling-points of metals at pressures below and above atmospheric, and the experimental results obtained. For pressures below 760 mm. the heating arrangement used was similar to that used for boiling-point determinations at atmospheric pressure [see Abstracts Nos. 1500 (1908) and 1712 (1909)]. A side tube was arranged down which temperature readings were taken with a Wanner optical pyrometer, and this tube was kept clear from fumes by a slow current of nitrogen or hydrogen. The principal results of the investigation are given in the following table, each value being the mean of several concordant experiments;—

Metal.	Pressure in mm.	Boiling-point.
Bismuth	102	1200°
	257	1810
Copper	100	1980
	257	2180
Lead	105	1820
	266	1420
Silver	108	1660
	268	1780
Tin	101	1970
	262	2100

To study the effects of high positive pressures on the boiling-points a much more elaborate apparatus was necessary, and various troubles arose; the observations of the metal surface were less definite than those obtained at lower pressures, and sublimation below the boiling-point seemed to be more pronounced. The following results were obtained :—

Metal.	Pressure in Atmos.	Boiling-point.	Metal.	Pressure in Atmos.	Boiling-point
Lead	1	1525°	Bismuth	16·5	2060°
	6·8	1870	Zinc	6·8	1120
	11·7	2100		11·7	1230
Bismuth	1	1420		21·5	1280
	6·8	1740		53	1510
	11·7	1950			

C. O. B.

941. *Orientation of Crystals of Ice in a Flux of Heat.* **H. T. Barnes.** (Nature, 83. p. 276, May 5, 1910.)—In a Bunsen calorimeter wherein the ice was produced by means of solid CO_2, it was found that from the solid mantle of ice there grew long needles and thin plates of ice which were perfectly oriented along the lines of the flow of heat. The crystals near the top of the mantle were directed at an angle upwards, while those at the base were normal to the mantle surface. This proves that the path of best conductivity in the ice crystal is along the principal axis. E. C. C. B.

942. *Dependence of the Specific Heats of Solids on the Temperature.* **A. Magnus** and **F. A. Lindemann.** (Zeitschr. Elektrochem. 16. pp. 269–272, April 15, 1910.)—Einstein [Abstract No. 489 (1907)] has derived, from the radiation theory, the following equation for the specific heats of solid bodies: $C = 8R\Sigma e^{\beta v/T}(\beta v/T)^2/(e^{\beta v/T} - 1)^2$, where v is the true infra-red frequency of the atom. The authors find that the atomic heats of the metals can be represented as a function of the temperature by Einstein's formula only by the introduction of a term proportional to $T^{3/2}$, which takes account of the work of expansion and of the specific heat of the electrons. Whilst the assumption of a specific frequency is sufficient with the metals, this is often not the case with the non-metals; yet with these a frequency can be determined which gives a concordant expression of the character of the curve. The specific frequencies are evidently related to the melting-point (S), atomic weight (A), and atomic volume (V), the values of $\sqrt{(S/AV)}$ running parallel with those of v, although there are considerable deviations from strict proportionality between the two series of numbers. The rapid rise of the atomic heats of certain elements in the neighbourhood of the melting-point is explained by the simultaneous rapid increase in the values of the coefficients of expansion, by which a rapid augmentation of $C_p - C_v$ is caused. T. H. P.

943. *Change of Emissivity of Metals with Temperature in the Short-wave Infra-red.* **E. Hagen** and **H. Rubens.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 28. pp. 467–487, 1910. Communication from the Physikal.-Techn. Reichsanstalt.)—An extension of previous work [Abstract No. 864 (1909)] to the part of the infra-red spectrum between 0·7 μ and 8·85 μ. The equation, Emissivity $= 86{\cdot}5\sqrt{(\sigma/\lambda)}$, where σ is the specific resistance in ohms per m.^{2}, and λ the wave-length in μ, holds only when $\sqrt{(\sigma/\lambda)}$ is very small compared with $\sqrt{80}$. With the shorter waves another term is required, and the equation, Emissivity $= 86{\cdot}5\sqrt{(\sigma/\lambda)} - 6{\cdot}67\,\sigma/\lambda$, holds even for the poorer conducting metals up to the limit of the visible spectrum. It is first verified that the change of emissivity with temperature for waves ten times as long as those of red light is virtually the same as in the long-wave region. The experiments with shorter waves are made first on Pt and the le Chatelier Pt-Rh alloy. For both of these metals the transition from the "optical" into the "electrical" temperature-coefficient takes place in that part of the spectrum lying between $\lambda = 2\,\mu$ and $\lambda = 4\,\mu$. In all, six metals were investigated, and for these the change of emissivity with temperature is very small. From $\lambda = 2\,\mu$, the change proceeds in the direction required by Maxwell's theory, and, in five of the metals, reaches at $\lambda = 5\,\mu$ the value given by the second equation stated above. G. E. A.

944. *Temperatures in the divided Bunsen Flame.* **D. W. Shea.** (Phys. Rev. 80. pp. 897–410, March, 1910.)—The highest temperature in a divided Bunsen flame is confined sharply to a small zonal segment of the inner conical shell, no matter what substances are used to colour the flame, nor what the distance is between the bases of the cones, provided that that distance is at least a few cm. The temperature of the inner conical shell is not changed by varying its distance from the outer conical shell, provided that the distance is more than 2 or 3 cm., nor by introducing through it metal vapours that burn in a flame above it and in the outer cone. The temperature distribution of the inner conical shell changes to one that increases from base to apex when the distance between the cones approaches zero. The temperature of the flames of metal vapour burning just above the inner cone is the same for all the vapours used, excepting near the tips of these flames, and it is not changed by varying the distance between the cones. The temperature of the outer conical shell increases from the base to the apex, and it is always greatest at the apex. The temperature of the outer conical shell increases when its distance from the inner cone decreases; also when it burns metal vapours introduced through the inner cone. For any given divided Bunsen flame, the parts having the higher temperatures show the larger electrical wanderings, whether the flame be simple or one coloured by any one of the elements studied. A. D.

945. *Laws of Convergent Combustion.* **J. Meunier.** (Comptes Rendus, 150. pp. 781–783, March 21, 1910.)—This phenomenon being catalytic in nature [compare Abstracts Nos. 660 (1909), 257 (1910)], it might be thought that the gas current brings the molecules into contact with the Pt-wire, and that this contact is sufficient for the maintenance of combustion and, hence, of incandescence, the assumption of an attraction among the molecules being unnecessary. But the same phenomenon is observed when the Pt-wire, previously heated, is introduced into a test-tube containing a mixture of cool gas and air, the tube being erect or inverted. In this tube there is no movement of the gas other than the eddy produced by the phenomenon itself. If the combustion were a mere contact action, the intensity of the incandescence would increase with the surface of the Pt-wire, whilst exactly the contrary is found to be the case. If the wire is replaced by a piece of Pt-foil rolled in the form of a cylinder, the reddening is most marked when the wall of the test-tube is distant 5 mm. from the wall of the Pt cylinder. The intensity of incandescence depends, as is known, on the composition of the gaseous mixture, and this is the case not only for coal-gas, but also for all other combustible gases or vapours; catalytic incandescence is, indeed, related to the explosive power of the gaseous mixture. The nature of the wire also has an influence on the incandescence, which is produced by most of the non-oxidisable substances, although at temperatures higher than that required for Pt. The combustion of coal-gas by the Auer mantle is a case of convergent combustion, and not of combustion by flame, as is, in fact, shown by its spectrum. T. H. P.

946. *Stefan's Law relating to Evaporation.* **P. Vaillant.** (Comptes Rendus, 150. pp. 1048–1051, April 25, 1910.)—Measurements of the rate of evaporation of ether, chloroform, and petroleum ether from cylindrical vessels 3·80 cm. in diam., closed by metal discs perforated in the centre with openings of 3, 2, 1, and 0·5 cm. respectively, and with the surfaces of the liquids at distances of 2·10, 1·66, 1·22, 0·78, and 0·34 cm. from the orifice, show that the rate of evaporation diminishes with increased distance of the surface of the liquid from the orifice, being approximately inversely proportional to the square root of the distance. The variation is less marked with a small opening, and for less volatile liquids. Stefan's law states that, other things being equal, the rate of evaporation is proportional to the linear dimensions of the orifice, but the author finds that the rate of evaporation increases more rapidly than this with the larger outlets, and it also depends

on the diam. of the surface of the liquid, the latter having less effect with less volatile solvents, and when the ratio of the size of the surface to that of the orifice is large. He concludes that for very small openings Stefan's law gives too low results; as the opening is enlarged these become correct, and with further enlargement the results are too high. The limits between which the law holds vary with the volatility of the liquid. W. H. Si.

REFERENCES.

947. *Electrical Recording Thermometers for Clinical Work.* **H. L. Callendar.** (Phil. Mag. 19. pp. 538–565, April, 1910. Paper read before the Physical Soc., Feb. 11, 1910.)

948. *Flow of Heat in a Lamina affected by Leakage at Edges.* **B. O. Peirce.** (Amer. Acad., Proc. 45. No. 13. pp. 355–360, April, 1910.)—In estimating the thermal conductivity of a substance by operating upon a slab of it, the opposite faces being at temperatures T_0 and T_1, the edges are often at uncertain temperatures, thus slightly vitiating the results. In the present paper the flow of heat is calculated for a square slab of given thickness, one face being at temperature T_0 while the other *and the edges* are kept at the lower temperature T_1. The detailed results are contained in two tables, and illustrated by two figures. E. H. B.

949. *Thermodynamic Behaviour of Radiation in a Moving Diathermanous Medium.* **J. Ishiwara.** (Mathematico-Physical Soc., Tōkyō, Proc. 5. 14. pp. 214–221, March, 1910.)—A mathematical discussion of the subject on the relativity principle, by which the Stefan-Boltzmann Law is obtained. E. H. B.

950. *Noble Gases and the Equation of State.* II. **H. Happel.** (Ann. d. Physik, 31. 4. pp. 841–846, March 15, 1910.)—The author replies to the criticisms of Rudorf [Abstracts Nos. 1568 (1909), 705 (1910)], who has stated that the data at present available are insufficient to permit of a choice being made among the various equations of state. The author endeavours to show that this view is untenable, and that only the improved form of van der Waals' equation given by him [Abstract No. 2090 (1909)] agrees approximately with the observations. T. H. P.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

951. *"Bound Mass" and the FitzGerald-Lorentz Contraction.* **W. C. Baker.** (Phys. Rev. 30. pp. 634–637, May, 1910.)—From the theory that regards electromagnetic momentum as being due to a mass of ether entrained or "bound" by the moving Faraday tubes, it follows that the component momentum per unit volume in the direction of the motion of the charged body is given by $4\pi\mu N^2 v \sin^2\theta$, where N is the polarisation, v the velocity, and θ the angle between N and v. The present paper shows a simple method of calculating from this idea expressions for both the transverse and longitudinal masses of the system on the supposition that the whole mass is electrical. If the charged particle moves along the axis of z and x, y, z, denote a point on one of the Faraday tubes when it is at rest and x', y', z' the same point when the particle is moving and the axes moving with it, then $x' = x$, $y' = y$, and $z' = z(1 - \beta^2)^{1/2}$, where $\beta = v/V$, V being the speed of light. This transformation is evidently the FitzGerald-Lorentz contraction. The polarisations in the two cases of motion and rest are shown to have the ratio, $N'/N_0 = \sin\theta \div (1 - \beta^2)^{1/2} \sin\theta'$. The z-components of the momenta *in corresponding volumes* are then found to have the ratio, $g'/g_0 = (v'/v_0)(1 - \beta^2)^{1/2}$. Since the transverse mass of a system is given by the quotient: (longitudinal) momentum by (longitudinal) velocity, it thus follows that the ratio of the transverse masses is $m'/m_0 = (1 - \beta^2)^{-1/2}$ in agreement with the relation obtained by Lorentz and experimentally verified by Bucherer in the case of the high-velocity particles from radium. Again, if a force F act on the system to increase the velocity v and momentum G we have $F = dG/dt = dG/dv \,.\, dv/dt = 1/V \,.\, dG/d\beta \,.\, dv/dt$. Hence the longitudinal mass is given by $m'' = 1/V \,.\, dg'/d\beta$, and the ratio of the longitudinal masses by $m''/m_0 = (1 - \beta^2)^{-3/2}$. It must be remembered that the FitzGerald-Lorentz contraction applies to the tubes of force, *i.e.*, to the field of the charged particle, and so to the actual systems built up of such particles. These considerations suggest that the question of the deformability of the electron itself tends to pass away, and we are led to the conception of the electron advocated by J. J. Thomson, viz., a simple point-charge, the whole inertia of which is due to the entrained ether. E. H. B.

952. *The Penetration Effect in Dielectrics.* **L. Malclès.** (Comptes Rendus, 150. pp. 1319–1321, May 23, 1910.)—The residual charges due to solid and liquid dielectrics have been compared, first when the metal plates have been in contact with the dielectric, and secondly, when they are separated from the metal plates by layers of substances (ozokerite) which are impermeable to electricity. In both cases identical results were obtained. Hence the residual charges cannot be due to penetration. The experimental results obtained with gutta, rubber, and vaseline oil are given. Pressures up to 800 volts were used. A. R.

953. *Observations of Atmospheric Electricity from a Balloon.* **A. Gockel.** (Phys. Zeitschr. 11. pp. 280–282, April 1, 1910.)—In conjunction with de Quer-

vain the author made a balloon ascent from Zürich in the morning of Dec. 11, 1909, and landed near Biel in the afternoon. There was a minimum of 750 mm. over Ireland on that day, a maximum of 770 mm. over Russia, and the reduced pressure over Switzerland was about 766 mm. The balloon was mostly above thick clouds, in bright sunshine; at the max. height of 4500 m. the temperature was −22° C. The Ebert apparatus gave $J_+ = 0{\cdot}462$, $J_- = 0{\cdot}470$, and therefore q approximately = 1 at the max. height. The Wulf electrometer, which at Freiburg generally marks a dispersion of 14 volts/hour and considerably higher values in frosty weather, rose to three times that value in the clouds, and sunk to 9·5 volts afterwards; there was a further temporary diminution at 2500 m. H. B.

DISCHARGE AND OSCILLATIONS.

954. *Ionisation by Bubbling.* **de Broglie and Brizard.** (Comptes Rendus, 150. pp. 969–970, April 18, 1910.)—It has been found by Bloch [see Abstract No. 602 (1910)], that certain liquids give ionisation when gases are bubbled through them, while others do not. The present investigation deals with the bubbling of gases through two non-mixing liquids, the lower one an active one in the above sense, and the upper one inactive. Small bubbles were produced in the lower liquid, and it was found that they carried with them an envelope of the lower liquid across the upper liquid, the envelope falling on the bursting of the bubbles. The gas evolved from the bubbles was subjected to an ultramicroscopic examination in an electric field, and charged centres were observed carrying in some cases multiple charges. The ionisation, however, was much less than in the case when the upper "inactive" liquid was absent. E. M.

955. *Mechanical Ionisation of Gases.* **de Broglie.** (Comptes Rendus, 150. pp. 1115–1118, May 2, 1910.)—The various mechanical processes for ionising gases were systematically studied—bubbling, agitation, breaking of jets, spraying. In each case the liquids investigated could be divided into active ones, giving multiply-charged centres whose mobility is reduced by Ra rays; and inactive ones, giving neutral centres chargeable by ionising radiations. To the former belong water, alcohol, ether, acetone, aldehyde, sulphuric acid, and aniline; to the latter, benzene, toluene, xylene, carbon tetrachloride, pentane, hexane, carbon bisulphide, and chloroform. Mercury produces no centres by bubbling. The classification into active and inactive liquids is the same whichever mechanical process is adopted. But the "activity" is probably due in every case to traces of water. The general rule is that ionisation is produced by the rupture of liquid surfaces. [See Abstracts Nos. 954, 1006 (1910).] E. E. F.

956. *Ionisation by a Flame of Carbon Monoxide.* **M. de Broglie.** (Comptes Rendus, 150. pp. 1425–1427, May 30, 1910.)—In a previous paper [see Abstract No. 698 (1907)] the author has shown that the ions produced by a flame of CO in air have a considerably greater mobility than those produced in a hydrogen flame. In the present investigation a comparison has been made of their mobility with that of the ions produced by radioactive radiation, and the author concludes that the mobilities are of the same order of magnitude, and that the ions are therefore probably identical. E. M.

957. *Variations of Current in Ionisation by Collision.* **E. Meyer.** (Deutsch. Phys. Gesell., Verh. 12. 6. pp. 253–274, March 30, 1910. Paper read before the 81. Deutsch. Naturforscher-Versamml., Salzburg. Phys. Zeitschr. 11. pp. 215–224, March 15, 1910.)—Disregarding the exponential law of decay, the number of atoms of a radio-active substance breaking up per sec. is not constant but subject to a certain variation about the average value [see Abstracts Nos. 626, 926 (1908)]. By analogy with this phenomenon a similar effect was expected from the following arrangement. Ionisation was produced by γ-rays from Ra in the gas between two parallel plates, one of which was connected to an electrometer. By reducing the pressure of the gas and connecting the other plate to a high potential the ionisation current was magnified by the production of fresh ions by collision. Using a balance method the way in which the irregular movements of the electrometer needle varied with the pressure of the gas, was investigated. If the irregularities of the current were to be ascribed only to the "Schweidler" effect, no difference ought to be observed for different pressures, but the experiments showed that this was far from being the case. The author gives a theory which accounts for the experimental results, the assumption being that the free path, over which the ions acquire the necessary energy to produce ions by collision, is not constant, but itself subject to variations similar to those in the kinetic theory of gases. E. M.

958. *Photoelectric Action of Alkaline Hydrides.* **J. Elster and H. Geitel.** (Phys. Zeitschr. 11. pp. 257–262, April 1, 1910.)—Metallic potassium, Na, Rb, and Cs were deposited on a silver deposit in a tube exhausted by means of a Gaede pump. The tube was then filled with hydrogen from a piece of Pd heated in a side tube. On heating the whole tube, the alkaline metals were converted into white crystalline deposits, probably identical with Moissan's hydrides. These hydrides were then exposed to kathode rays, and became strongly coloured, potassium becoming bluish-violet, Rb the same but fainter, Cs greenish, and Na a brownish-yellow. Stronger colours were produced by exposing the metals to a glow discharge in an atmosphere of hydrogen. All these hydrides proved to be strongly photoelectric, potassium hydride giving a current of 4 microamps. in feeble sunlight. The coloured deposits must be regarded as solid solutions of the alkali metal in the hydride. The photoelectric sensitiveness increases with the depth of the colouration. The colour is somewhat unstable, especially under the influence of heat and strong kathode rays. E. E. F.

959. *Saturation Curves of Photoelectric Effect.* **E. Bloch.** (Comptes Rendus, 150. pp. 1113–1115, May 2, 1910.)—The photoelectric currents obtained with solid metals (Hertz-effect) show no true saturation curves, the current always increasing somewhat with increasing p.d. This was studied by the author by means of monochromatic light from a mercury arc. Saturation was most closely approached with the shortest waves. The currents were calculated from Langevin's theory, which considers the diffusion of the ions produced by the photoelectric action. The agreement was complete within the limits of error (1 per cent.). The mean free path of the electrons was found to be $2{\cdot}4 \times 10^{-4}$, whereas the value indicated by the kinetic theory of gases is $0{\cdot}57 \times 10^{-4}$. The speed of emission, determined with the help of a magnetic field, is 5×10^7 cm./sec. for zinc, which agrees well with Lenard's value. E. E. F.

960. *Photoelectric Fatigue of Zinc.* **E. Ullmann.** (Ann. d. Physik, 32. 1. pp. 1–48, April 28, 1910. Extract of Dissertation, Rostock.)—Refutes Aigner's allegation that illumination itself is the cause of the photoelectric fatigue of zinc. The apparent effect in the case of ultra-violet light is due to the formation of ozone. When the vessel is widely varied its dimensions are found to have a distinct influence. In damp air zinc shows more fatigue than copper, but this is due to the moisture itself, and not to the oxygen. The effect is probably conditioned by the formation of H_2O_2. In ozone both copper and zinc show fatigue, but sensitiveness is restored by removing the ozone. As regards gases, the smallest photoelectric effect is obtained in dry hydrogen. Dry air gives a value 8 times higher, moist air 6 times, and dry CO_2 17 times. The zinc surfaces are best cleaned by scraping, and not with emery paper. The former gives a greater constancy of the initial effect and a smaller fatigue. [See Abstracts Nos. 2957 (1904), 1884, 1675 (1907), and 840 (1908).] **E. E. F.**

961. *Positive and Negative Ions in Canal Rays of Hydrogen, Oxygen, and Nitrogen.* **W. Wien.** (Phys. Zeitschr. 11. pp. 377–379, May 1, 1910.)—It has long been known that side by side with the positively charged atoms in the canal rays there are negatively charged particles. It seems probable that the ratio of the number of positively and negatively charged particles to those which are without charge depends upon the nature of the gas. For the purpose of these experiments a Rubens linear thermopile is used. This can be moved by means of a screw through the bundle of canal rays, and so the heat-effects in the bundle itself and also in its immediate neighbourhood can be tested. If it is accepted that the thermoelectric currents are proportional to the energy of the canal rays, it is possible to obtain an energy curve by moving the thermopile through the rays. When the energy curve is taken at sufficiently low pressures with a magnetic field acting, two strongly marked maxima are noted, the second of which is due to the bundle of deflected rays. With hydrogen the energy of the positive ions is found to be essentially greater than that of the negative ions. It is quite otherwise with oxygen. In this case, under the usual conditions the energy maximum of the deflected negative ions is greater than that of the positive. The preponderance of negative ions in the case of oxygen appears to be due to the action of mercury vapour. Canal rays in nitrogen behave quite similarly to those in hydrogen. **A. E. G.**

962. *A New Circumstance in the Formation of Kathode Rays.* **L. Dunoyer.** (Comptes Rendus, 150. pp. 970–978, April 18, 1910.)—Some sodium is freed from all traces of oil and placed in a side branch to a vacuum tube. The vacuum-tube walls and the electrodes are carefully freed from occluded gases, and when the length of spark equivalent to the resistance of the tube reaches some cm. the side bulb containing the sodium is heated. The sodium distils and condenses on the cool sides of the main tube and on parts of the electrodes. The vacuum is maintained by pumping during this distillation, and when the pressure is sufficiently low the side of the tube on passing the discharge is seen to be dotted with a large number of small green fluorescent spots, which are very bright, clearly defined, and quite fixed in position. These spots still appear when the vacuum is too low for any ordinary fluorescence of the walls of the tube to take place. It is further shown that the phenomenon only occurs when the condensed drops of sodium are sufficiently small. Similar results are obtained with potassium and rubidium.

All metals do not act equally well for electrodes. It has been observed with steel and Pt, but not with Al. If the air is allowed to enter slowly and the tube is again evacuated, the spots do not reappear, thus seeming to indicate that the state of their surfaces is important. Besides the spots, there is a cone of kathode rays having for its apex a very bright orange point on the electrode. The explanation offered is, that when the pressure is so low an afflux exists incapable of bringing about the formation of the ordinary kathode rays because its energy is below a certain limit, yet this afflux will be able under certain conditions to raise the temperature of the extremely minute drops, and these will then emit a large number of electrons, which, accelerated by the field, constitute the kathode rays observed. Other experiments are in progress. A. E. G.

963. *Ion-velocity in Argon.* **J. Franck.** (Deutsch. Phys. Gesell., Verh. 12. 6. pp. 291–298, March 30, 1910.)—In argon the ion-velocities of the positive ions are normal, about 1·37 cm./sec. per volt/cm. in the field; but those of the negative ions are peculiar, being as much as 206·8 in "pure" argon, falling to 1·7 when there is 1·2 per cent. of oxygen present, and remaining at 1·7 for percentages of oxygen up to 10. The theoretical value (Lenard) is 1·66. Helium is even more inert than argon, but may be even more sensitive to diatomic impurities, for it does not present the extraordinarily high velocities of positive ions shown by argon; but the author is now investigating this. [See Abstract No. 181 (1910).] A. D.

964. *Specific Velocities and Reunion of Ions in Hexane.* **G. Jaffé.** (Ann. d. Physik, 32. 1. pp. 148–178, April 28, 1910.)—The chief results of this research may be stated briefly as follows: The specific velocity of the positive ion produced in hexane by radium radiation was determined as $6·08 \times 10^{-4}$, that of the negative ion as $4·17 \times 10^{-4}$ cm. per sec. per volt/cm. The diffusions coefficients were then, under certain assumptions, derived as $1·50 \times 10^{-6}$ and $1·08 \times 10^{-6}$. The reunion of the ions in hexane was investigated by a direct and an indirect method, and appeared in agreement with the formula: $dn/dt = -\alpha'' n^{1·64}$, where $\alpha'' = 1·86 . t^{0·64}$, thus differing appreciably from the theoretical formulæ: $dn/dt = -\alpha n^2$ and $dn/dt = -\alpha' n^{3/2}$. [See also Abstracts Nos. 1124 (1906), 439 (1908), 938 and 1797 (1909).] E. H. B.

965. *Effect of Radiations on Brush Discharge.* **A. E. Garrett.** (Phys. Soc., Proc. 21. pp. 648–652; Discussion, p. 652, Dec., 1909.)—Willows and Peck [see Abstract No. 1036 (1905)] have shown that the electric discharge produced by a Wimshurst machine is under certain conditions sensitive to the rays from Ra. The present paper deals with further experiments on the subject, the sparks from an induction coil also having been investigated. When using an induction coil the author finds that the Ra has to be placed much nearer in order to produce any visible effect on the discharge than when using a Wimshurst machine. The author has examined the discharge microscopically and also by a revolving mirror, and concludes that the brush owes its sensitive nature to the oscillatory nature of the discharge, and that the action of the Ra may be due to side discharges set up by its radiations.

E. M.

966. *Effect of Changes in the Pressure and Temperature of Gases upon the Velocity of the Negative Ions produced by Ultra-violet Light.* **A. F. Kovarik.**

(Phys. Rev. 30. pp. 425–445, April, 1910.)—The method used to determine the velocity is a modification of that used by Rutherford. One of two parallel plates is illuminated by the ultra-violet light and charged with an alternating potential, and the electrical charge carried by the ions to the second plate is observed for different values of the alternating potential. Values proportional to the charge received are plotted against the corresponding values of the potential, and for a certain range of potential the curve obtained has a straight portion which, if produced, hits the axis of potentials at P_0. Knowing the value of P_0, the rate of alternation, and the distance between the plates, the value of the velocity can be obtained from the relation $v = d^2/P_0 t = 2nd^2/P_0$, where n represents the number of alternations of the field per sec. The following conclusions are arrived at: With atmospheric pressure and ordinary room temperature the velocity of the ions produced by ultra-violet light, when results are reduced to 760 mm. pressure, is found to be 2·04 cm./sec. per volt/cm. for dry air, and 1·01 cm./sec. for dry CO_2. In air saturated with water-vapour at 25° C. the velocity is 1·64 cm./sec., while in CO_2 saturated with water-vapour at 26° C. it is only 0·806 cm./sec. The velocity of the negative ions at ordinary temperatures and pressures is the same for ions from Zn, Pt, or brass. The velocity in both dry air and dry CO_2 varies inversely as the pressure from 760 mm. down to 200 mm. In dry air below 200 mm. the product of the velocity by the pressure increases as the pressure is reduced, the increase being slow at first but very sudden at about 100 mm., so that at 8·8 mm. the product is found to be 10 times as great as that at atmospheric pressure. This indicates that below 200 mm. the size of the ion is increasingly smaller as the pressure is reduced. In dry CO_2 below 200 mm. there is likewise a sudden increase in the product of velocity by pressure, but in this case it occurs at a somewhat higher pressure than in air. For temperatures ranging from 84·5° to 698° abs. the velocity of the negative ions in dry air at atmospheric pressure increases uniformly with the temperature. When results are reduced to a common gas density the velocity remains unchanged from 700° to 400° abs., but below that temperature it diminishes, until at the temperature of liquid air it is only about ½ its value at the higher temperatures. In this region, therefore, the cluster of molecules forming an ion increases in size as the temperature is lowered. A. E. G.

967. *Pressure of the Electric Wind in Hydrogen containing traces of Oxygen.* **A. P. Chattock** and **A. M. Tyndall.** (Phil. Mag. 19. pp. 449–460, April, 1910.)—In a previous paper [Abstract No. 1466 (1908)] the authors have shown that if the amount of oxygen in the hydrogen be reduced to a fraction of 1 per cent. certain phenomena accompanying the negative discharge are modified in a marked way. The velocity of the ions is obtained by the wind-pressure method. The principle of this method may thus be described: If a point discharges a current of strength c through a uniform tube of cross-section a against a plate at a distance z from the point, the specific velocity of the ions, V, is given by the expression $V = (c/a)/(dp/dz)$, where p is the average pressure of the electric wind per unit area of the plate; it being assumed that the plate fills the tube, and that ions of one sign only are present in the distance dz. In the present experiments it is found that when more than 0·5 per cent. of oxygen is present in the hydrogen the values of V by the wind-pressure method are about the same as those previously found [$v + = 5{\cdot}8$, and $V - = 7{\cdot}6$]; but in the case of the negative discharge alone, a very striking decrease in the value of dp/dz, *i.e.*, increase in the apparent value of V—, is observed as the hydrogen is made purer, the

increase being more than fortyfold in the purest gas obtainable; in other words, the gradual removal of the last 1 per cent. of oxygen from the hydrogen gives rise to a marked fall in the electric wind when a negative point discharges through the gas against a plate. This fall is probably due to the discharge of positive electricity from the plate, and may even amount to a slight reversal of the wind in very pure hydrogen. The fall is accompanied by a glow upon the plate, which may be regarded as further evidence for such a back discharge. The wind pressures for different distances between the point and plate are plotted, and within the limits of percentage change of oxygen the straight part of the negative wind-pressure curves becomes shifted parallel to itself through a distance which may amount to 8 cm. It is suggested that this shift may be connected with the growth of ions from the corpuscular magnitude to that of the ordinary ion. None of the above effects occur with the positive discharge in hydrogen, which is practically uninfluenced by the pressure of oxygen up to the highest percentage (8·7) used. A. E. G.

968. *Size of Particles projected by a Kathode in Kathodic Projection.* **L. Houllevigue.** (Comptes Rendus, 150. pp. 1287–1288, May 17, 1910.)—Experimenting with Ag kathodes and collecting the projected Ag on a strip of glass connected with a Wheatstone bridge, thereby enabling the change in resistance to be measured, the author finds the size of the projected particles to be about 22–26 $\mu\mu$, which is of the same order of magnitude as the size of Bredig's colloidal silver, and he concludes that the particles projected from a kathode are not essentially different from the granules of colloidal metals [see Abstract No. 1279 (1909)]. W. H. Si.

969. *Striæ Distances, and the P.D. between the Striæ of the Positive Luminous Discharge.* **F. Wehner.** (Ann. d. Physik, 32. 1. pp. 49–85, April 28, 1910. Extract from Dissertation, Leipzig, 1909.)—Cylindrical tubes of diams. varying from 10 to 800 mm., and electrode distances 1 to 2½ m. are used. The current is obtained from a continuous-current dynamo. The gases used are commercial nitrogen, and hydrogen, oxygen obtained from $KMnO_4$, and CO_2 from $NaHCO_3$. The method of determining the distances between the striæ, and the p.d. between successive striæ is fully described, but for these the original paper must be consulted. The following are the chief results obtained: With increasing current the striæ distances at constant pressure approximate to a constant value. These constant distances between the striæ are dependent upon the pressure in the manner indicated by Goldstein, and the connection between pressure and distance can be represented by $l = f^{(r)}/p^m$ in which $l =$ distance between striæ, $p =$ pressure, and $r =$ radius of tube. This law, however, does not hold in the case of CO_2. The connection between these quantities can be extended to the form $l = c\frac{r^{1-m}}{p^m}$ and the value of m is 0·58 for hydrogen and 0·82 for nitrogen, while c has the value 2·14 for hydrogen and 2 for nitrogen. At a given pressure the p.d. between the striæ diminishes with increasing current to a constant value. The relationship between this constant value (V) and the pressure can be represented (*a*) by $V = \kappa p^\lambda$ (for a tube of 6 cm. diam. containing hydrogen λ has the value 0·195 and κ the value 14·8), and (*b*) by $V = V_i + C'p^{-m}$ in which m represents the same as in the first equations. For two different researches with a tube of 6 cm. diam. $C' = 10{\cdot}88$ and $V_i = 6{\cdot}88$, $5{\cdot}69$. These values obtained for V_i indicate that the ionising tension required to produce electrons from hydrogen is about 6 volts. With increasing tube width the p.d. between the striæ under otherwise similar conditions is greater. The exact relationship between the p.d. and the tube width is, however, not determined. A. E. G.

970. *Dielectric Cohesion in Neon.* **E. Bouty.** (Comptes Rendus, 150. pp. 1330–1333, May 30, 1910.)—In the rare monatomic gases the amount of dielectric cohesion not only affords a valuable control of the purity of the gas, but also gives a precise method of quantitative analysis. The limiting value of the dielectric cohesion in neon appears to be 5·6—an extremely low figure. [*Erratum*, p. 1790, June 27, 1910.] A. D.

971. *Rectifying Effect in Point and Plane Discharges.* **R. F. Earhart** and **C. H. Lake.** (Phys. Rev. 30. pp. 460–470, April, 1910.)—In this investigation the authors have sought to secure quantitative measurements on the rectifying effect between an electrified point and a plane. The special form of discharge chamber used, in which one electrode is a plane brass plate and the other a Pt point, is described. One terminal of a battery is earthed direct, and the other is connected through a liquid resistance to one electrode of the discharge chamber, and a voltmeter in parallel with the chamber. The other electrode of the discharge chamber, and the other terminal of the voltmeter are earthed. From the curves given in which voltage required to produce luminosity is plotted against pressure, it can be seen that for the point negative the results obtained are similar to those which Carr and others obtained with parallel plates, but for the point positive the voltage required for a discharge at any given pressure is higher than the voltage required at the corresponding pressure with the point negative; and further, the critical pressure (*i.e.*, pressure at which p.d. producing a luminous discharge is a minimum) for point positive is higher than for point negative. The potentials where rectification is possible obviously lie between the lines representing the discharge for point positive and the point negative. Within the limits of the experiments the most favourable regions for this effect lies near the critical pressure and the longer spark-gap. The critical pressure varies with the distance of the electrodes in every case, but for any given separation of the electrodes the critical pressure for the negative point is less than for the positive point. The results obtained for hydrogen are quite similar to those obtained in air. The minimum potential required for the discharge is, however, considerably less than for air, and occurs at higher pressures. A. E. G.

972. *Absorption of Energy by the Passage of an Alternating Current through a Gas at Atmospheric Pressure.* **A. Chassy.** (Comptes Rendus, 150. pp. 1305–1307, May 23, 1910.)—Continuation of previous work [see Abstract No. 1484 (1909)]. Measurements of the heat evolved in the condenser during the passage of the alternating current through a hydrogen dielectric show that the heat disengaged is almost proportional to the current. The current is made up of two parts—a displacement current and a conduction current; as the tension increases the former kind diminishes, and at high tensions the ratio of current to tension appears to become constant. G. E. A.

973. *The Two Values of the Potential at which Disruptive Discharges take place.* **P. Villard** and **H. Abraham.** (Comptes Rendus, 150. pp. 1286–1289, May 23, 1910.)—For a given discharge-gap there exist two values of the pressure at which disruptive discharges ensue. The smaller, which may be called the aigrette potential, is the one at which a discharge sometimes ensues, but there exist greater values of the p.d. at which discharges never ensue. The larger is the normal disruptive voltage, and is the only one that is observed in certain gases. For every p.d. between these two values a steady and continuous silent discharge takes place, and the anode is more or less covered by a luminous corona. The nature of this corona is very analagous to the electrolytic corona studied by Violle and Chassagny. [*Erratum*, p. 1714.] A. R.

974. *Multiple Reflections of Electric Waves between Reflecting Surfaces.* **L. E. Woodman and H. W. Webb.** (Phys. Rev. 30. pp. 561–598, May, 1910.)—Short electric waves (λ = 7 cm.) generated by a Righi oscillator are directed in a parallel beam through two screens of resonators, placed perpendicular to the beam and parallel to each other. The distance between the two screens is varied and the energy transmitted through and reflected by the screens is measured by a linear resonator with thermo-couple. The reflection experiments are performed by the interferometer arrangement, the movable mirror being replaced by the two screens and the fixed mirror being set so as to deflect the energy incident upon it. Tuned and non-selective receivers are used, and the conclusion arrived at is that the non-selective receiver is far superior for all work involving determination of wave-lengths. The tuning curves indicate that the radiation from a Righi vibrator consists of a short spectrum, and that the maximum on the tuning curves depends on the peculiarities of the receiver. Preliminary experiments show that with the Righi vibrator set up by the experimenters the beam of energy sent out by the parabolic mirror is very nearly parallel. The theory of the case under experiment is given, and the experimental results agree well with the theory. The intensity of the transmitted and reflected radiation passes through a series of maxima and minima as the distance between the screens is increased, the distance between successive maxima or minima being very nearly equal to the half wave-length of the incident radiation. The wave-lengths of radiation transmitted and reflected by one screen of resonators are determined by the Boltzmann mirror method, and it is found that the screen of resonators acts like a selectively reflecting surface for the incident waves which are very nearly in resonance with the resonators. The transmittivity of a glass plate, both with and without resonators pasted on its surface, is also investigated. Under proper conditions of dielectric constant and of thickness of plate, more energy may be transmitted with resonators on the plate than by bare glass. Also the transmittivity of a glass plate depends on the wave-length of the incident radiation. T. P. B.

975. *Frequency of Electrical Oscillation affected by Metal of Spark-gap.* **M. Wien.** (Phys. Zeitschr. 11. pp. 282–287, April 1, 1910.)—The nature of the metal which forms the electrodes of the spark-gap of a condenser circuit affects not only the damping but also the frequency of oscillation. The author's experiments show that, compared with Mg, all metals give a decreased frequency. This is especially true of Cu and Ag, which, under certain circumstances, may give an increase of wave-length of about 1 per cent. Although this decrease of frequency is always accompanied by an increase of damping, it is too great to be explained by the increased damping alone. Experiments are performed to investigate whether Mg electrodes affect the frequency. A circuit is made to oscillate at one time with, at another time without, a spark-gap." The slight change in frequency can be fully accounted for by the increase of damping. Thus Mg does not show the effect mentioned above. Magnesium, therefore, is recommended for use as electrode metal, as, in addition, the spark-damping is very small and is not affected by the state of the electrode surface, while the sparking potential is unaffected by ultra-violet light. **T. P. B.**

976. *Use of Wehnelt Kathode Tubes in Wireless Telegraphy.* **J. Würschmidt.** (Deutsch. Phys. Gesell., Verh. 12. 8. pp. 361–375, April 30, 1910.) —Under a given p.d. a Wehnelt kathode tube [see Abstract No. 2672 (1904)] lights up suddenly at a particular pressure. At a pressure in the neighbourhood of this critical pressure the tube is in a somewhat unstable condition and may be made to light up in several ways, as, for instance, by a sudden change in an external electric field, by the rays from an arc lamp, by Röntgen and radium rays. The tube in this condition may be used as an indicator of electric waves. The receiving antenna is connected to earth through a coil wrapped round the tube. When electrical oscillations are induced in the receiver the tube lights up. The max. working distance mentioned is 12 m., with antennæ 1 to 2 m. long. [Compare Tissot, Abstract No. 2073 (1906).] **T. P. B.**

ELECTRICAL PROPERTIES AND INSTRUMENTS.

977. *Electrical Properties of Selenium.* **II. L. S. McDowell.** (Phys. Rev. 30. pp. 474–481, April, 1910.)—This second paper deals with the recovery of selenium after excitation by Röntgen rays, and the chief results may be summarised as follows: (1) The forms of the recovery curves for Röntgen-ray excitation and for light excitation are identical. (2) The form of the curve for recovery after light depends only upon the magnitude of the initial change in conductivity and not at all upon the time required to produce that change. (3) The rate of recovery after Röntgen rays is slower than that after light. (4) Hence diffusion is probably not an important factor in producing the deviation from the straight line of the selenium recovery curves. [See Abstracts Nos. 368 (1904), 1111, 2077 (1906), and 1597 (1909).] **E. H. B.**

978. *Electron Theory Studies in Metallic Solid Solutions.* **R. Schenck.** (Ann. d. Physik, 32. 2. pp. 261–290, May 12, 1910.)—Several observers have shown that the Wiedemann and Franz law of the constancy of the ratio existing between the thermal and electrical conductivities of metals is not very rigid, and that the values of the ratios for the different metals differ from each other and also from the theoretical values of Drude and Reinganum [Abstracts Nos. 1276, 2199 (1900)]. Important exceptions, in the case of pure metals, are the metals of the platinum group, which show low values, and Bi and Fe, which show high values, while the alloys generally show high values. According to Drude's theory, the conduction of heat and electricity is effected by free electrons to which the kinetic gas laws are applicable. Electric conductivity depends upon two factors—concentration of the electrons and the internal frictional resistance. Now, if increasing concentration in a solid metallic solution results in an increase of resistance, the increase may be due to a reduction in the concentration of the electrons or an increase in the frictional resistance. From a theoretical consideration of the thermoelectric and optical properties of alloys observed by various workers, the author has attempted to solve the problem of the effect of the dissolved foreign molecules in a solid metallic solvent, in causing a diminution in the electric conductivity and a consequent increase in the ratio of the thermal and electric conductivities. The increase of electric resistance is due to an increase in the friction of the electrons, caused by their collision and absorption of kinetic energy from the molecules of the slowly diffusing added metals. Consequently the ratio of the thermal and electrical conductivities in metallic solid solutions is larger than in the pure metals, and increases with increasing concentration. The concentration of the electrons in a metal can be calculated from the ratio of the conductivity of a metallic solid solution of known concentration to that of the pure metallic solvent. The thermoelectric properties confirm these hypotheses; the alloy is usually positive, and a relation exists between the e.m.f. of the couple and the log. of the ratio of the conductivity of the alloy to that of the pure metal. Further, a relation exists between the e.m.f., the concentration of the metallic solid solution, and the concentrations of the electrons, from which the latter can be calculated. The results agree with those obtained by Drude from the optical constants of the metals. **F. C. A. H. L.**

979. *Resistance of Thin Plates to Alternate Currents.* **J. Bethenod.** (Jahrbuch d. drahtlosen Telegraphie, 2. 4. pp. 397–401, 1909. Lumière Electr. 9. pp. 282–288, Feb. 19, 1910.)—The author assumes that the thickness $2h$ of the plate is small in comparison to its width and length, in which case the current density δ depends only on time t and on distance x from the median plane of the plate. The max. current density is shown to be $\delta = A\sqrt{(\epsilon^{2bx} + \epsilon^{-2bx} + 2\cos 2bx)}$, where $b = \sqrt{(2\pi\omega\mu c)}$; c being conductivity, μ permeability, and $\omega = 2\pi n$, where n is frequency. As a result the alternate-current resistance—

$$r_a = \frac{b}{2c} \cdot \frac{\sinh 2bh + \sin 2bh}{\cosh 2bh - \cos 2bh},$$

or if r_c be resistance to continuous current—

$$r_a = r_c \cdot bh \cdot \frac{\sinh 2bh + \sin 2bh}{\cosh 2bh - \cos 2bh}.$$

If the plate is of copper and the thickness $2h$ is 0·1 cm., the resistance to a current of frequency 100,000 is $r_a = 2{\cdot}48 r_c$; while if the thickness be decreased to 0·01 cm. the resistance only increases by about 20 per cent. **J. E.-M.**

980. *Electric Resistance and Hardness of Steel.* **C. Barus.** (Phys. Rev. 30. pp. 347–349, March, 1910.)—The author gives a summary of results obtained, in continuation of former researches by Strouhal and himself [Wied. Ann. 7. p. 383 (1879); 11. p. 930 (1880)] on the relation between the thermoelectric power and the specific resistance of steel varying in temper from hard to soft. As in a previous paper [Abstract No. 215 (1910)], tempered steel is regarded as a mixture of hard and soft molecules, and the conclusion arrived at is that the phenomena attending variations in temper afford an index to the dissociation in solid media, subject to time and temperature. **G. W. DE T.**

981. *Resistance of Bismuth.* **R. Seidler.** (Ann. d. Physik, 32. 2. pp. 337–381, May 12, 1910. Extract of Dissertation, Leipzig, June 26, 1909.)—The author has observed that after a continuous current, which has been passing

through a bismuth wire, is broken, the bismuth is the seat of an e.m.f. He investigates this effect. A definite time after the current is broken contact is made between the ends of the wire and a condenser, which latter is then discharged through a galvanometer. Times are regulated and contacts made and broken by a pendulum interrupter; in this way the e.m.f. between the ends of the wire may be determined at any time after the current is broken. A manganin wire under the same circumstances shows no effect. The e.m.f. falls off rapidly, but not in an exponential manner; it has the same sign as the p.d. between the ends of the wire when the current is flowing. The sharpness of the break of the current has no effect upon it. The ends of the wire may be short-circuited for an instant without destroying the e.m.f. The magnitude of the e.m.f is about 1 per cent. of the applied p.d. and is proportional to the current which was passed. The more pronounced the crystalline structure of the bismuth the greater is the effect and the slower does it fall off. Wires made from fine powder and bismuth in liquid state do not show the effect. Compression of the metal reduces the observed e.m.f.; at high temperatures the e.m.f. falls off slower than at lower temperatures. A magnetic field parallel to the wire increases the e.m.f. In a transverse magnetic field there is, in addition to the above, another effect, which is of opposite sign, and falls off less rapidly. T. P. B.

982. *Mutual Inductometers.* **A. Campbell.** (Phil. Mag. 19. pp. 497–507, April, 1910. Paper read before the Physical Soc., Jan. 21, 1910.)—In a previous paper [see Abstract No. 468 (1908)] mutual inductance bridges are described by which self-inductances, even of very small magnitude, can be readily measured. In this paper more of these methods are discussed, and, in particular, the uses to which variable mutual induction coils can be applied are described. A variable mutual induction coil is called a mutual inductometer. The author first describes a modified mutual inductance bridge of great sensitivity. He discusses the measurement of effective resistance at high frequencies, and shows how, by means of the mutual inductometer, we can employ a null method for the magnetic testing of iron. Finally he shows how his methods can be usefully employed for testing current-transformers.
A. R.

983. *Thomas's Laws regarding the Direction of Thermoelectric Currents.* **C. H. Lees.** (Phil. Mag. 19. pp. 508–512, April, 1910. Paper read before the Physical Soc., Feb. 25, 1910.)—The author criticises the laws regarding the direction of thermoelectric currents enunciated by Thomas. These laws may be stated as follows: If the ratio of the electrical conductivity to the heat conductivity of the better electrical conductor be *greater than* the corresponding ratio for the worse electrical conductor, then the thermo-current flows from hot to cold in the *better* electrical conductor. The second law is obtained by writing *less than* and *worse* for the words in italics in the preceding sentence. They may be combined into one by stating that the current flows from hot to cold in the conductor for which the ratio of the electrical conductivity to the heat conductivity is the greater. Lees tests this law by applying it to thirteen metals whose constants are accurately known. The results give no confirmation of the law, which may therefore be considered as conclusively disproved. A. R.

984. *Thomson-effect in Copper, Iron, and Platinum.* **O. Berg.** (Ann. d. Physik, 32. 3. pp. 477–519, June 2, 1910.)—The method of measuring the

Thomson-effect is first described and discussed, and the principle on which the measurements depend is shown diagrammatically. The final form of apparatus adopted is described. The method used has in many respects the advantages of a compensation method, and is, in particular, moderately free from the errors which arise through the secondary heating current. As a result of the research it is found that Cu shows a small positive Thomson-effect with a small temperature-coefficient; with Pt a large negative value with small temperature-coefficient is obtained; while with Fe there is an extraordinarily large temperature-coefficient. The Thomson-effect in this case has the value 0 at − 50° C.; it has positive values below that temperature and negative values above. The alteration with the temperature follows approximately a linear law. The so-called Tait's law [proportionality with the absolute temperature] is not even approximately fulfilled. A. E. G.

985. *Standards of Resistance and Electromotive Force.* **R. Jouast.** (Soc. Int. Élect., Bull. 10. pp. 187–206, March, 1910.)—The values of certain resistance coils were found in terms of the mercury standards of resistance of the National Physical Laboratory and the Reichsanstalt, and of the secondary mercury standards of resistance of the International Bureau of Weights and Measures. The general conclusions are that—

N. P. L. ohm ...... — Reichsanstalt ohm = 0·00002 ohm very nearly.
N. P. L. ohm ...... — {Ohm realised from French standards} = 0·00012 " "
Reichsanstalt ohm — {Ohm realised from French standards} = 0·00011 " "

The first difference is in very good agreement with that found by Rosa in 1909 [Abstract No. 896 (1909)]. A large number of Weston cells have been constructed, and their e.m.f.'s compared with 7 cells from the National Physical Laboratory. The changes in e.m.f. of 10 groups of cells may be obtained from the following table:—

Group.	Made.	Mercurous Sulphate.	Mean E.M.F. at 20° C.	
			Soon after Manufacture.	In Nov., 1909, or March, 1910.
E	May, 1908	Electrolysis, A.C.	1·01858	1·01851
J	July, 1908	" D.C.	46	28
S	Dec., 1908	" D.C.	46	42
D	Feb., 1909	" D.C.	50	87
P	May, 1909	" A.C.	50	49
P C N	June, 1907	Precipitated	88	25
I II X	April, 1908	"	22	84
T	May, 1909	Electrolysis, A.C.	49	41
G	Feb., 1909	" A.C.	22	49
a	Feb., 1909	Precipitated	46	48

The method most favoured for manufacturing the mercurous sulphate is the alternating-current electrolytic method. F. E. S.

986. *Simple Arrangement for Measuring Magnetic Fields.* **C. Chéneveau** (Comptes Rendus, 150. pp. 1046–1048, April 25, 1910.)—The effect of a magnetic field on the level of a liquid in a U-tube is multiplied by using two liquids, one paramagnetic, *e.g.*, $MnSO_4$, and the other diamagnetic, *e.g.*, phenol, mixture of C_6H_6 and CCl_4, the difference in density $\rho - \rho_1$ being 0·023. With two such liquids a rise of level h was obtained eighteen times as great as with the magnetic liquid alone. In the arrangement given for field measurement the meniscus is kept at the same level by means of a small air compressor, and the change of pressure is read off from a differential manometer. The field intensity H can then be calculated from $H^2 = 2h(\rho - \rho_1)g/(k + k_1)$, where k and k_1 are the susceptibilities of the two liquids. The value of h thus obtained was 6·7 cm. as compared with 0·5 mm. (180 : 1) when the magnetic liquid alone was used; the field was 2800 units. G. E. A.

987. *A New Construction of Aluminium Windows of a Kathode Tube and some Demonstrations with Kathode Rays.* **W. E. Pauli.** (Zeitschr. Instrumentenk. 30. pp. 183–187, May, 1910. Communication from the Radiolog. Inst. d. Univ., Heidelberg.)—The first part of this paper contains the description of the improvements of the kathode tube with Al window, and an arrangement is next described by means of which the most important properties of the kathode rays can be demonstrated to a larger audience. The new arrangement improves the windows of kathode tubes in two directions: (*a*) it increases the durability of the window, and (*b*) the quantity of kathode rays escaping from the tube will possibly be made greater. The top part of the tube is conical in shape and about 4 cm. diam. It consists entirely of a sort of hollow brass plug carefully ground to fit the tube. Through the end of this plug some 20 holes of about 2 mm. diam. are bored. These holes are in the middle part of the end of the plug, and are so placed that at the most only a metal bridge about 1 mm. wide is left between the holes. On these holes a copper wire net is placed, and then on this the aluminium window. The whole is carefully cemented with suitable medium. The wire of the gauze used is 0·1 mm., and the space between two wires 0·28 mm. It is important that the net should be most carefully ground smooth on an oilstone on the side towards the Al window. An arrangement is described for showing (*a*) that the kathode rays spread out in straight lines; (*b*) the absorption of kathode rays in different gases; and (*c*) a proof of the negative charge of kathode rays. A. E. G.

988. *Ropiquet's Interrupter with Variable and Decreasing Self-inductance Stages.* **E. Spéder.** (Archives d'Él. Médicale, 18. pp. 398–403, May 10, 1910.)—Consists of a mercury interrupter of the rotating jet pattern, working in a gas atmosphere, and in which the jet in its rotation completes the circuit through a series of electrodes against which the mercury impinges, each succeeding electrode completing a circuit containing a smaller self-inductance than the one preceding it. The rise of the current is by this means flattened out and the inverse current at make converted into a series of small pulsations, which are of no account in the working of the tube. In the model illustrated, made by Drault, there are ten electrodes and twenty self-inductance coils, enabling suitable combinations to be selected. L. H. W.

ALTERNATING CURRENTS AND MAGNETISM.

989. *Self-demagnetising Factors of Magnets.* **S. P. Thompson and E. W. Moss.** (Phys. Soc., Proc. 21. pp. 622–682; Discussion, pp. 682–688, Dec., 1909. Electrician, 63. pp. 871–872, Sept. 10, 1909. Abstract.)—Self-demagnetising factors were determined for bar magnets of circular and rectangular cross-section, the material being annealed Swedish iron. The bars, which were of various lengths, had all a cross-section of exactly 1 sq. cm. A magnetising solenoid over 90 cm. long was used, and a ballistic method employed to measure the magnetisation at the centre of the specimen. The B-H curves obtained were compared with those for a forged ring of the same material, and the self-demagnetising factors (N) deduced from the difference between the values of H giving the same value of B. The following table exhibits some of the results for circular magnets compared with those previously obtained by Du Bois and Riborg Mann:—

Dimension Ratio. (Length/Diam.)	N. Thompson and Moss.	N. Du Bois.	N. Mann.
10	0·198	0·216	0·2550
15	0·108	0·1206	0·1400
20	0·069	0·0775	0·08975
30	0·036	0·0393	0·04604
40	0·0228	0·0238	0·02744

Results are given for bars of rectangular sections with cross dimensions varying from 10 : 1 to 1 : 1. The factors are always less than for bars of equal circular section and equal length, and were greatest for square sections. **A. D. R.**

990. *Reduction of Hysteresis Losses by High-frequency Currents.* **R. Goldschmidt.** (Elektrotechn. Zeitschr. 31. pp. 218–221, March 3, 1910.)—The author's investigation was made with a Koepsel permeameter, and had as its object the examination whether the effects produced by high-frequency currents on longitudinally magnetised iron could not be utilised also for technical purposes apart from its use in magnetic detectors. Numerous curves are given which show the effect of cross-magnetisation upon the hysteresis and the remanence. When the magnetising coil of the Koepsel apparatus is supplied with direct current and the core—which in this case was a soft iron tube through the interior of which an alternating demagnetising current was passed—is subjected to an alternating current, an alternating current of double the frequency appears in the direct-current magnetising coil. The author finds, in agreement with Gerosa and Finzi that a direct-current cross-magnetisation decreases the size of the hysteresis loop and the permeability considerably when the iron is subjected to longitudinal cyclic magnetisation. He finds, however, in addition, that if the induction is increased so that the max. flux-density is the same as before the application of the cross-magnetisation, then the hysteresis loop, though flattened out, has exactly the same area as it had without cross-magnetisation. It is approximately arrived at, from the curves, that about 40 per cent. of the work saved (due to diminished hysteresis) has to be used to produce the demagnetisation, but in the case of the magnetic detector the high frequency must cause such an eddy-current loss that the ratio will be much less favourable. **L. H. W.**

991. *Kerr-effect in Ferromagnetic Compounds and Alloys.* **S. Loria.** (Konink. Akad. Wetensch. Amsterdam, Proc. 12. pp. 835–845, May 26, 1910.)—Mirrors of the following substances were examined in the field of a small Du Bois electromagnet, solar rays being exclusively employed: $CuO . Fe_2O_3$, $CaO . Fe_2O_3$, $FeO . Fe_2O_3$, $Ti_2O_3 . Fe_2O_3$, Cr_2O_3, invar and Heusler alloy. The dispersion of the Kerr-effect is shown by means of tables and curves.

With cupriferrite the rotation is positive in the violet, a maximum occurring in the blue; the rotation decreases to zero at about 587 $\mu\mu$, becoming negative for longer wave-lengths; a minimum occurs between 640 and 670 $\mu\mu$. The rotations are very small throughout. The curve for magnetite is very nearly the same as that obtained formerly by Du Bois for the same specimen; further, the point of zero rotation is at 464 $\mu\mu$. No Kerr-effect was found with calcium ferrite, ilmenite, or chromic oxide. With invar the rotation is exclusively negative in the region investigated, and there is only a slight variation with wave-length, there being a flat minimum in the orange. The Heusler alloy proved to be magneto-optically ineffective. The saturation values of magnetisation given are: Cupriferrite, 140 c.g.s.; magnetite, 358; and invar, 580.

G. E. A.

992. *Magnetism and Allotropic Modifications of Iron.* **S. Hilpert.** (Zeitschr. Elektrochem. 16. pp. 390–394, June 1, 1910.)—The author questions whether change in magnetic properties or the accompanying evolution in heat can be regarded as evidence of allotropic modification. He points out that there is no discontinuity in the permeability-temperature curve for iron, and that the transition from the magnetic to the non-magnetic state occurs at somewhat varying temperatures. The heat evolution is then ascribed solely to the liberation of molecular energy of the magnetised material when the body becomes non-magnetic. In the absence of any microscopic evidence to the contrary [see, however, Abstract No. 752 (1910)] the α-β and β-γ changes are considered to have no real significance.

A. D. R.

993. *Measurement of Magnetic Susceptibility.* **P. Pascal.** (Comptes Rendus, 150. pp. 1054–1056, April 25, 1910.)—A method is described of determining the susceptibility of feebly magnetic solids by measuring the force tending to draw the solid into the pole-gap of a powerful electromagnet. The solid is suspended from the beam of a delicate balance, and the tractive force is measured by weights placed in a scale-pan attached below the specimen.

A. D. R.

994. *Determination of Magnetic Susceptibility.* **C. Chéneveau.** (Comptes Rendus, 150. pp. 1317–1318, May 23, 1910.)—The author compares the accuracy attainable with Curie's balance, the U-tube, and Pascal's method [see preceding Abstract]. He shows that the first has as small a probable error (1 to 2 per cent.) when only moderate fields are used as have the two latter even with employment of intense fields and cumbrous electromagnets. The disturbance due to heated air when large magnetising currents are used is also probably an important source of error in the two last-mentioned methods. **P. Pascal.** (Comptes Rendus, 150. pp. 1514–1515, June 6, 1910.)—Pascal criticises C. Chéneveau's views on this subject. As a result of numerous experiments he considers the probable error with Curie's balance to be 1 or 2 per cent., with the U-tube 0·5 per cent., and with his own apparatus, *loc. cit.*, less than 0·7 per cent. The heating effect in the last case is small and does not appreciably affect the weighings.

A. D. R.

995. *Saturation Intensity of Magnetisation.* **P. Weiss.** (Soc. Franc. Phys., Bull. 2. pp. 165–185, 1910. Journ. de Physique, 9. pp. 373–393, May, 1910.)—Tests were conducted on iron, nickel, cobalt, and magnetite to find the manner in which the magnetic moment per gm. (σ) approached its saturation limit as the magnetising field was increased to a

very large value. The fields employed ranged up to 9250 gauss and were given by a powerful electromagnet. A small solenoid of silk-covered copper wire was placed axially in the pole-gap and connected up to a ballistic galvanometer. One pole-piece was bored through, and this gave a means of withdrawing a small ellipsoidal specimen of the material under test from the interior of the helix. The accompanying throw of the galvanometer gave a measure of σ. The method of calculating H and σ are described. The following table summarises the chief results :—

Substance.	I_∞.	σ.
Iron at 19° C.	1706	$216{\cdot}5\left(1-\frac{7{\cdot}9}{H}\right)$
Nickel at 18°	479·0	$54{\cdot}49\left(1-\frac{9{\cdot}7}{H}\right)$
Cobalt at 17°	1412	$162\left(1-\frac{1{\cdot}11}{H^2}\right)$
Magnetite at 16·2°	476·5	$90{\cdot}72\left(1-\frac{19}{H}\right)$

where I_∞ is the saturation intensity of magnetisation, and the formula for σ gives the magnetic moment per gm. in intense fields (H) and hence shows the law of approach towards saturation. A. D. R.

996. *Magnetisation of Liquid and Solid Oxygen.* **H. Kamerlingh Onnes** and **A. Perrier.** (Konink. Akad. Wetensch. Amsterdam, Proc. 12. pp. 799–835, May 26, 1910. Communication No. 116 from the Phys. Lab., Leiden.)—A research on the change of specific susceptibility (magnetisation per gm. per unit field) of oxygen with temperature, two methods being used. In the first was measured the magnetic attraction exerted on a column of the liquid (Quincke's method); in the second, the max. couple exerted by a homogeneous field on an ellipsoid. In the first method, the specific susceptibility χ is found from $\chi = 2zg/H$, where z is the rise of the liquid and H the field strength. The precautions necessary in dealing with a liquefied gas, and the construction of the complicated glass double-vacuum apparatus used are minutely detailed. From the values found at temperatures from 60·9 to 90·1° abs. the specific susceptibility can be represented by $\chi = (2284 \times 10^{-6})/\sqrt{T}$, where T is the absolute temperature. In the second method, the measurements were made on a solid silver ellipsoid immersed in the liquid oxygen, and the results obtained agreed closely with those found by the first method. In the case of solid oxygen, an ellipsoidal specimen was made by repeatedly solidifying liquid oxygen within a small glass ellipsoid. The values of χ (solid) found can be expressed by $1690 \times 10^{-6}/\sqrt{T}$. It is considered that the law of proportionality of χ to $1/\sqrt{T}$ at lower temperatures gradually transforms into that of proportionality to $1/T$ (Curie's law) at higher temperatures, and that each of these laws may be only approximative to the same function over different ranges of T. It does not seem impossible that the law $\chi \propto 1/\sqrt{T}$ may change at lower temperatures to $\chi = \text{constant}$. The assumption to which this is equivalent, viz., that the magnetic motions of the electrons cease at absolute zero, is one to which the above experiments seem to lead.

G. E. A.

997. *Measurement of Intense Magnetic Fields.* **P. Sève.** (Comptes Rendus, 150. pp. 1809–1811, May 23, 1910.)—The paper describes a balance designed to measure the action of a magnetic field on a conductor of known dimensions placed perpendicular to the lines of force and carrying a known current.

This enables the field intensity to be calculated. The apparatus is somewhat similar to the instrument used by Weiss, but embodies several improvements. The conductor is a copper film mounted on a glass holder, and as it can carry 10 amps., the weights used reach 20 gm. with H = 10,000. A method of experimenting is described which eliminates the effect of the field on the glass carrier and other parts of the balance. A. D. R.

998. *Propagation of Magnetic Storms over the Earth.* **L. A. Bauer.** (Terrestrial Magnetism, 15. pp. 9–20, March, 1910.)—Comparison of records of the magnetic storm of May 8, 1902, lead the author to believe that the commencement of a magnetic storm is not strictly instantaneous all over the earth. Other magnetic disturbances were therefore examined, and the conclusions reached are (1) that the abruptly beginning storms, in which the effects are usually small, are propagated over the earth generally eastwards, though also at times westwards, at a speed of about 7000 miles per min., so that a complete circuit of the earth is made within 4 min.; (2) that the larger and more complex disturbances frequently travel with considerably less velocity; and (3) that the time of commencement of the storm may be appreciably different for the various magnetic elements according to the character of the operating systems. A. D. R.

999. *Magnetic Storms.* **L. A. Bauer.** (Terrestrial Magnetism, 15. pp. 21–30, March, 1910.)—It is pointed out that alterations in the earth's magnetic condition, whatever their nature or origin may be, appear to be distributed over the globe according to a law profoundly dependent upon that governing the distribution of the earth's own primary magnetic forces. Thus, on analytical examination, we have reproduced in the secular variations the same harmonic terms which define the initial field of the earth. It is hence desirable to take typical magnetic disturbances and analyse the observed effects into spherical harmonic terms so as to determine how much is due to currents outside and how much to currents within the earth. The author makes an examination of the storm of Jan. 26, 1903, and shows that the disturbance magnetic north pole was in the general region of the atmospheric magnetic north pole. The increase in H, along with the diminution in V in the N. magnetic hemisphere and the increase in V in the opposite hemisphere, points to the storm being due chiefly to external currents.

A. D. R.

ELECTRO-PHYSIOLOGY AND ELECTRO-THERAPEUTICS.

1000. *Action of very Intense High-frequency Currents upon the Human Arterial Pressure.* **J. Bergonié, A. Broca, and G. Ferrié.** (Archives d'Él. Médicale, 18. pp. 41–60, Jan. 25, 1910.)—In continuation of former work [see Abstract No. 2108 (1907)], the present communication only deals with the construction of a more powerful high-frequency equipment. The new auto-conduction coil has ten turns (of copper strip 5 cm. wide and 1 mm. thick), wound on a frame 30 cm. × 1 m. With a capacity of 0·4 mfd. this inductance ($L = 5{\cdot}5 \times 10^4$) should give a frequency of 36,000 per sec. The actual frequency found by the wave-meter employed was 27,000 per sec. To obtain the frequencies (400,000–500,000 per sec.) employed by previous experimenters, the capacity would have to be 200 times smaller, and consequently the energy available would have been insufficient. The authors, however, successfully applied the method of direct excitation of the auto-conduction coil (by placing it in shunt to a part of the primary oscillating circuit). In this way, with ¼ of the condenser (0·8 mfd.) in the main circuit and a condenser of 0·028 mfd. in the shunt circuit containing the auto-conduction coil, a single frequency of 400,000 per sec. was obtained, and currents of 18–24 amps. were observed in the latter coil, as compared with 2·5–8 amps. obtainable with the coil placed in series in the usual way. The spark-length was 17 cm. The special oil-insulated condenser is described, and also some experiments upon the change in wave-length when a barrel of salt water was inserted in the coil. Illustrations are given and a diagram of the connections.

L. H. W.

1001. *Method of Klingelfuss for Measurement of Röntgen Rays.* **A. J. de Beaujeu.** (Archives d'Él. Médicale, 18. pp. 438–442, May 25, 1910.)—This is a verification of the accuracy of measurements obtained with the "sclerometre" of Klingelfuss, this providing an easy means of obtaining exact quantities of Röntgen rays, from a given bulb, at a fixed distance. This is done by making use of the relationship EIT = a const., in which E is the sclerometre reading, I the current in secondary in milliamps., and T is the time required to produce a constant effect upon a photographic plate. A diagram showing the arrangement of the apparatus is given. A. E. G.

1002. *Exposure in Medical Radiography with or without Reinforcing Screen.* **H. Guilleminot.** (Comptes Rendus, 150. pp. 1623–1625, June 13, 1910.)—It is very commonly the practice to employ neither unit nor formula for obtaining radiographs. The object of the present paper is to determine the best exposures. In a photographic plate it is important to obtain sufficient detail in both light and shade. Suppose, for example, that in a thin part of the plate behind a bone a radiation of 5 units M gives an emergent quantity $Q = 0{\cdot}079M$, and at a neighbouring point a quantity $Q_1 = 0{\cdot}068M$. The contrast between these two elements will be represented by the difference between $0{\cdot}068M$ and $0{\cdot}079M$. Now the ratio 0·068/0·079, or in general Q_1/Q, remains the same when the incident dose is made to vary, but this constant ratio will be more or less useful according to the absolute value of Q; if Q is too small the contrast will be poor, if too large then the contrast will disappear and inversion may even take place. The problem, then, is to determine the incident dose capable of producing the best results (for a given region, a given radiation, and a known plate) with an arbitrary and constant factor of contrast Q_1/Q. To do this two manipulations which are described in detail are necessary: (1) to make a scale of contrasts upon the plate, and (2) to measure the fraction of radiation transmitted by the most transparent and most opaque parts of the region to be radiographed. Experiments are also carried out using Gehler's reinforcing screen with Jougla plates. A. E. G.

REFERENCES.

1003. *On the Motion of an Electrified Sphere.* **A. W. Conway.** (Roy. Irish Acad., Proc. 28. pp. 1–15, Feb., 1910.)—Mathematical.

1004. *Electric Dust Figures on Insulators.* **G. Quincke.** (Ann. d. Physik, 32. 1. pp. 91–147, April 28, 1910.)—An elaborate series of experimental researches following up the work of Lichtenberg and P. Riess. The results are contained in several tables and about fifty figures, most of them photographically reproduced. The original should be consulted for the details. E. H. B.

1005. *Temperature and Emission of Light of Canal Rays.* **J. Kœnigsberger.** (Phys. Zeitschr. 11. pp. 379–389, May 1, 1910.)—This is mainly a theoretical paper based on researches carried out in conjuction with J. Kutschewski. The following are the chief points considered; The emission of light by the canal rays and their apparent dissociation at low pressures; generation of phosphorescence by the neutral particles; range of the positive and neutral particles; behaviour of mercury vapour and the unit of positive electricity; velocity of the positive portion of the canal rays; canal rays under higher pressures; line-emission and absorption as temperature phenomena; temperature conditions with emission of light by canal rays. A. E. G.

1006. *Ionisation by Spraying of Liquids.* **L. Bloch.** (Comptes Rendus, 150. pp. 967–969, April 18, 1910.)—It is known that when a liquid is sprayed against a solid obstacle ionisation is produced. In the present investigation it was found that with many liquids ionisation is also produced in the initial formation of the spray. The liquids which give this effect are also those which give ionisation when air is bubbled through them [see Abstract No. 602 (1910)]. E. M.

1007. *Canal Rays in a Parallel Electric Field.* **J. Stark.** (Phys. Zeitschr. 11. pp. 171–179, March 1, 1910.)—The author describes various experiments he has carried out with the object of investigating the hypothesis that in a bundle of canal rays there exists a back and forward transformation of positive, negative, and neutral rays. Some of these experiments are similar to those of J. J. Thomson and Wien, whilst others were performed by a new arrangement depending on observation of the Doppler-effect. J. J. S.

1008. *Electrochemical Equivalent of Silver.* **F. Laporte and P. de la Gorce.** (Soc. Int. Élect., Bull. 10. pp. 157–185, March, 1910.)—The complete report of an investigation on the silver voltameter. A brief account has already appeared [see Abstract No. 436 (1910)]. F. E. S.

1009. *Eddy-current Losses in Iron.* **H. G. Möller.** (Deutsch. Phys. Gesell., Verh. 12. 8. pp. 385–402, April 30, 1910.)—A mathematical discussion is given of a method of estimating, on the electronic theory of magnetism, the eddy currents produced in iron situated in an alternating field. Illustrative examples are added, and the results are compared with the experimental investigations of Hausrath and found to be in satisfactory agreement. A. D. R.

1010. *Some of the Problems of Ocean Magnetic Work.* **L. A. Bauer.** (Terrestrial Magnetism, 14. pp. 161–175, Appendix pp. 175–176, by A. W. Rücker and A. Schuster, Dec., 1909.)

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1011. *Thulium.* **C. James.** (Amer. Chem. Soc., Journ. 32. pp. 517–518, April, 1910.)—The author has obtained about 250 gm. of the bromate of Cleve's thulium by the continued fractionation of the rare earth bromates more soluble than that of erbium. Thulium salts are of a pale bluish-green colour, which is, however, readily destroyed by minute amounts of erbium, the solution becoming first yellowish-green, then yellow, colourless, and finally pink as the content of erbium increases. The author is proceeding with the determination of the atomic weight of the metal, and the material is still undergoing fractionation, in order to ascertain if a single element is being dealt with. T. H. P.

1012. *Action of α-Rays on Water.* **K. Bergwitz.** (Phys. Zeitschr. 11. pp. 273–275, April 1, 1910.)—Using an intense polonium preparation, the author has determined the quantities of hydrogen and oxygen which are evolved in a given time when the preparation is inserted in water. A determination of the whole kinetic energy of the α-particles emitted from the polonium showed that only about $\frac{1}{10}$ of it appears in this way as chemical energy. E. M.

1013. *Influence of Radium Emanation on Equilibrium in a Gaseous System.* **F. L. Usher.** (Chem. Soc., Journ. 97. pp. 389–405, March, 1910.)—The author has investigated the action of RaEm on ammonia [compare Cameron and Ramsay, Abstract No. 1312 (1908)], the results obtained being as follows. Ammonia is decomposed by radium emanation at the ordinary temperature and the decomposition is nearly irreversible, recombination not being observed to occur to a greater extent than 0·86 per cent. Decomposition of solidified ammonia by solidified emanation proceeds with appreciable velocity at —190°. The decomposition at the ordinary temperature follows approximately the course of a unimolecular homogeneous reaction when correcting factors for the decay of the emanation and alteration of its efficiency with time are introduced. If the ratio of ammonia to emanation molecules does not exceed 10,000 to 1, the statement that each atom in disintegrating produces the same effect is not strictly true, on account of the waste involved when the system is rich in emanation. The largest effect observed was the decomposition of 134,800 mols. of ammonia per atom of emanation. The energy required to produce the largest effect observed was about 1 per cent. of the energy actually expended during the production of that effect. All experiments with gases in glass vessels in presence of the emanation are complicated by the fact that gas is driven into the glass and can only be recovered by heating strongly; hydrogen is thus driven into glass to a greater extent than nitrogen, and as much as 0·24 c.cm. of the former gas was lost during a single experiment. (Corrigendum, Ibid. p. 1193.) T. H. P.

1014. *Physical-Chemical Notation.* (Faraday Soc., Trans. 5. pp. 252–258, Feb., 1910. Report of Sub-Committee, presented to the 7th Internat.

Congress of Applied Chemistry, London, 1909.)—The symbols submitted by the sub-committee will be found in col. I. of the following table, those adopted by the Berlin Congress being given, for comparison, in col. II.

I.	II.	Name of Quantity.
		Mechanical and Chemical.
l	—	Length.
q	—	Area.
v	v	Volume.
p_r, P	p, P	Pressure, ordinary and osmotic.
δ	δ	Density referred to water.
Δ	Δ	Density referred to air.
ρ	—	Viscosity.
γ	—	Surface tension.
A	a	Atomic weight (O = 16).
M	M	Molecular weight ($O_2 = 32$).
ν	—	Valency.
g	—	Intensity of gravity.
c, C	—	Concentration in equivalents per litre.
η	η	Concentration in equivalents per c.cm.
t	t	Time.
K	K	Equilibrium constant.
k	—	Velocity constant.
p_k, v_k, t_k	π_0, ϕ_0, θ_0	Critical quantities — pressure, volume, and temperature.
π, ϕ, θ	π, ϕ, θ	Reduced quantities—pressure, volume, and temperature.
R	R	Gas constant.
		Heat and Thermodynamics.
T	T	Temperature, absolute.
t	θ	Temperature, Centigrade.
c	c	Specific heat.
c_p, c_v	c_p, c_v	Specific heat at constant pressure and constant volume respectively.
$C_p = c_pM$ $C_v = c_vM$	$C_p = c_pM$ $C_v = c_vM$	Molecular heat at constant pressure and constant volume respectively.
Q	Q	Quantity of heat.
U	U	Internal or total energy
A	—	Free or available energy.
h	—	Latent or bound energy.
L	—	Latent heat of change of state.
η	—	Entropy.
J	A	Mechanical equivalent.
		Optical.
λ	—	Wave-length.
N	N	Refractive index.
R_G	—	Refractivity $\left(=\frac{N-1}{\delta}\text{, Gladstone}\right)$.
R_L	—	Refractivity $\left(=\frac{N^2-1}{N^2+2}\cdot\frac{1}{\delta}\text{, Lorentz}\right)$.
MR	—	Molecular refractivity.
$[\alpha]$	—	Specific rotatory power.
M $[\alpha]$	—	Molecular rotatory power.

I.	II.	Name of Quantity.
		Electrical.
I	I	Current strength.
R, r	W	Resistance.
E	E	Potential.
ϵ	ϵ	Single potential of an electrode or decomposition tension of an ion.
ϵ_h	ϵ_h	Single potential measured against the normal hydrogen electrode, the latter being taken as = 0.
ϵ_c	ϵ_c	Single potential measured against the normal calomel electrode, the latter being taken as = 0.
K	—	Dielectric constant.
F	F	Faraday constant (= 96540 coulombs).
κ	κ	Conductivity.
Λ	Λ	Equivalent conductivity $\left(=\frac{\kappa}{\eta}\right)$.
Λ_∞	Λ_∞	Equivalent conductivity at infinite dilution.
u, v		Equivalent conductivity of the kathion and anion respectively.
U, V	—	Velocity of the kathion and anion respectively in cm./sec. in a potential gradient of 1 volt/cm.
α	γ	Degree of dissociation.
n	—	Transport number.

L. H. W.

1015. *A Simple System of Thermodynamic Chemistry based upon a Modification of the Method of Carnot.* **E. W. Washburn.** (Amer. Chem. Soc., Journ. 32. pp. 467–502, April, 1910.)—The author describes a simplification of the cyclical process method of Carnot, which reduces the cycle of necessary operations to a single step and allows the desired thermodynamic equation to be written down by inspection, and illustrates its use by applying it to the derivation of a number of fundamental relations. In connection with the application of the engine to the subject of chemical equilibrium the author points out that the law of mass action is not an expression of the condition of equilibrium in a system whose equation of state is $p(v-d) = RT$. Further, the derivation of the law of the constancy of the solubility product for a solute which dissociates in solution does not involve any assumption regarding the nature of the law which regulates the equilibrium between the undissociated molecules and their products of dissociation. Consequently the theoretical basis of the solubility product law in the case of strong electrolytes is not destroyed by the fact that they do not obey the law of mass action. It is lastly shown that many of the equations which contain the van't Hoff factor i involve an unnecessary number of assumptions and that each equation can be split up into two simpler equations, one involving only the ions and the other the un-ionised molecules. A. F.

1016. *Direct Union of Carbon and Hydrogen at High Temperatures.* II. **J. N. Pring.** (Chem. Soc., Journ. 97. pp. 498–511, March, 1910.)—Further investigations [compare Abstract No. 504 (1907)] show that pure carbon combines directly with pure hydrogen at all temperatures above 1100°. At 1200°, however, the velocity of the reaction is so small in the absence of any catalyst that the estimation of the exact equilibrium value of methane is somewhat uncertain. An experiment extending over 22 hours at 1200° appeared to give the limiting value of 0·35 per cent. of methane, but this could not be confirmed by approaching the equilibrium from the other side, as the decomposition of small amounts of methane by pure carbon at 1200° proceeds even more slowly than the synthetic reaction. At 1500° an equilibrium value of 0·17 per cent. was apparently approached within about 2 hours. More definite equilibrium values were obtained by using carbon with a surface deposit of Pt. In this case the reaction was greatly accelerated between 1050° and 1500°, and the same percentage of methane was finally obtained by synthesis and decomposition, namely, 0·55 per cent. at 1200° and 0·30 per cent. at 1500°. Above 1550°, the proportion of methane begins to rise with the temperature, this being probably due to decomposition of acetylene, although the amount of the latter below 1350° was found to be too small to detect. Experiment shows, however, that acetylene changes quickly to methane and ethylene above 1500°, and that the methane formed is comparatively stable. The presence of CO has no apparent effect on the final equilibrium or on the velocity of reaction in the synthesis or decomposition of methane at any temperature employed by the author. T. H. P.

1017. *Behaviour of Copper Slags in the Electric Furnace.* **L. T. Wright.** (Amer. Inst. Mining Engin., Bull. 39. pp. 221–222, March, 1910.)—Contains results of experiments on fusing samples of copper furnace-slags in an electric furnace. These show that a large amount of metallic iron is reduced and that this iron carries practically all the Cu, Au, and Ag, and more than 50 per cent. of the sulphur, of the original slag. The metallic buttons formed were clean, hard, but not brittle. C. O. B.

1018. *Calculation of Electrode Losses.* **C. A. Hansen.** (Amer. Electrochem. Soc., Trans. 16. pp. 329–352; Discussion, pp. 352–362, 1909.)—Gives the results of an attempt to analyse the electrode losses occurring in an electric furnace, with a view of finding out how far these losses are determinable from published data and also what conditions affect them. The following are given as the most important data for calculating losses: (1) Length, the entire length of electrode from centre of water-jacket to extreme hot end. (2) Resistivity of graphite under conditions applicable to a temperature-difference of 3000° C. = 0·00032 ohms per cub. in. Resistivity of carbon under the same conditions may be taken as 0·00072 ohm per cub. in. (3) Heat conductivity of graphite, 3200° C. — 200° = 1·65 watt-sec. per sec. per 1 deg. C. for 1 in. length and 1 sq. in. section = 0·162 c.g.s. unit. Heat conductivity of carbon under same conditions, 0·165 watt-sec. per sec. per 1 deg. C. for 1 in. length and 1 sq. in. section = 0·0162 c.g.s. unit. (4) Contact resistance may be taken as 0·075, 0·029, and 0·025 ohm. per sq. in. for brass to graphite at current densities through the contact area of 24, 36, and 48, amps. per sq. in. respectively. A numerical example is given of the calculation of losses for titanium carbide furnace electrodes. Resistances of graphite and carbon electrodes are given and also the effect of fixing the electrodes at temperatures from 1200 to 3500°. To the *discussion* **J. W. Richards** contributes figures showing heat conductivities of graphite and carbon which he considers more accurate than those given in the paper. [See Abstract No. 465 (1910).] C. O. B.

1019. *Laws of Electrode Losses.* **A. E. Kennelly.** (Amer. Inst. Elect. Engin., Proc. 29. pp. 267–288, March, 1910.)—Considers from a mathematical point of view how far the temperature variation in electric and thermal resistivities of the electrodes modifies Hering's laws of electrode losses in electric furnaces [see Abstract No. 465 (1910)]. The author concludes that Hering's first two laws may be amended as follows: (*a*) The combined loss through the cold end of an electrode is equivalent to the sum of the loss by heat conduction alone (when there is no current) and approximately half the C^2R loss, the exact fraction depending on the temperature-coefficients of the resistivities. With constant resistivities the fraction will be ½. (*b*) The above combined loss will be least when the loss by heat conduction alone is equal to the Joulean loss through the cold end. The total loss will then be approximately equal to the total Joulean loss and very little heat will flow into or out of the furnace. With constant resistivities this resultant furnace flow will be nil. C. O. B.

1020. *Electrode Losses.* **E. F. Roeber.** (Amer. Electrochem. Soc., Trans. 16. pp. 368–376; Discussion, pp. 376–391, 1909.)—This paper also investigates, from a theoretical and mathematical point of view, as to how far the assumption of constant thermal and electric conductivities of electrodes holds good in practice in connection with Hering's laws of electrode losses. When the electrical conductivity is constant and the thermal conductivity alone varies by a straight-line law, no complicated formula is necessary; this indicates that it is largely the variation of the electrical conductivity which gives rise to a correction factor. C. O. B.

1021. *Chilling or Heating Action of Electrodes.* **C. Hering.** (Metallurgical and Chem. Engin. 8. pp. 188–190, April, 1910.)—This paper considers analytically and mathematically the choice which may sometimes arise in determining the proper proportions of electrodes for furnaces, between allowing the loss in the electrode to slightly chill or heat the product in the furnace, as either may be adopted at a sacrifice of the other. The difference is due to the variations of the conductivities with the temperature. It is shown that with an electrode material having a negative temperature-coefficient, the total loss could be diminished if desired by making the section somewhat larger than that required for no flow of furnace heat and allowing it then to chill the furnace somewhat. On the other hand, with materials like iron, which have a positive temperature-coefficient, it is shown that the total loss may be reduced by decreasing the section. There is a certain section in each case, however, at which the loss is a minimum. The greater the change of resistivity with temperature, the greater will be the reduction of power-loss which becomes possible by operating at a minimum loss instead of with no chilling action and with no high temperature within the walls. The conclusions are that, in general, the corrections due to differences in electrical resistivity and thermal conductivity of electrode material are too small to be considered in practice and that the engineer need only make the section a little larger for materials with a negative coefficient and a little smaller for those with a positive temperature-coefficient. [See also Abstracts Nos. 465 and 1019 (1910).] C. O. B.

1022. *New Method of measuring Conductivities of Electrodes.* **C. Hering.** (Amer. Electrochem. Soc., Trans. 16. pp. 317–324, 1909.)—Describes a new method for measuring the mean thermal and electrical conductivities of furnace electrodes, in order to find the mean conductivities to be used in determining the best ratio of length and cross-section of an electrode. A rod of the material under examination is embedded in a heat-insulating material, except at the ends, which are water-jacketed. A relatively large current is passed which will raise the temperature of the embedded part, the highest temperature being at the middle point, at which place a thermo-electric pyrometer is inserted. When the pyrometer ceases to rise for a given current, the temperature of the centre and the water-cooled ends are noted, together with the current and voltage. The product of the current and voltage gives the heat-flow, in watts, which is leaving at the two terminals. The heat conductivity is determined from the formula $k = 0{\cdot}02986\ \mathrm{WL/TS}$, in which k is the mean heat conductivity in gm.-cals. per sec. per sq. in. for 1 deg. C. per inch; L is length of embedded part in inches; T the difference in temperature between the middle and the ends, and S the cross-section of the rod in sq. in. The mean electrical resistance for the range of temperature used in the experiments is obtained by the formula $r = \mathrm{ES/CL}$, in which $\mathrm{E} = $ volts and $\mathrm{C} = $ amps. C. O. B.

1023. *Proportioning of Electrodes for Furnaces.* **C. Hering.** (Amer. Inst. Elect. Engin., Proc. 29. pp. 285-334, March, 1910. Electrician, 65. pp. 482-484, July 1, and pp. 526-529, July 8, 1910. Abstract.)—Points out that the usual rules for proportioning electrodes have been based on such factors as allowable current densities, least practicable resistance (hence shortness and large cross-section), lowest heat conduction, summation of losses due to electric resistance, and heat conduction, &c. The author shows that these rules are not only entirely inadequate, but are quite incorrect. The fundamental principle of the present analysis of the electrode problem is that the heat gradient at the hot end should be zero; that is, the line representing it should be horizontal at that end. This can only be obtained by having the temperature of the hot end of the electrode equal to that of the furnace, and this is accomplished by so proportioning the electrode that the current passing will raise it to the furnace temperature [see Abstract No. 1021 (1910)]. Current density as a basis of electrode design is shown to lead to incorrect proportions and need not be considered as a determining factor. The usual rule for making the resistance as low as possible is a mistake. The resistance for the most economical operation is fixed by the temperature, current, and material. Instead of trying to keep the outside terminals as cool as possible, as was formerly the practice, it is stated that they should be so designed as to let them get as hot as possible. Electrodes should be made as small as possible. The author also finds that the desirable qualities of electrodes do not depend on either the electric or thermal conductivity alone, but on certain relations between the two, and these qualities have been abandoned as a basis of proportioning and two new measures of electrode qualities are used, viz., "electrode voltage" and "specific cross-section." The various properties as electrodes are given for graphite, carbon, iron, and copper. The method used for these determinations was the one described in the preceding Abstract. Tables and curves of these properties are given and separate curves for the comparison of the properties for the different materials. These comparisons may be summarised as follows: *Current.*—These show that at about 1500° C. a graphite electrode will carry over 8 times as much current as will one of carbon of the same size; iron will carry over twice as much as graphite and nearly 7 times as much as carbon; the current capacity of copper is about 45 times that of carbon and 14 times that of graphite. *Current densities.*—The cross-sections in all the test-bars being the same, the above also represent the relative values of the current densities. *Watts.*—The curves for all four materials are seen to be nearly diagonal lines, indicating that the watts increase nearly in proportion to the temperature. *Electrical resistivity.*—The four materials show great differences in this property; at 1400° C. the relative values are about: Copper, 1; iron, 10; graphite, 72; carbon, 840. *Thermal conductivity.*—The heat conductivities differ far less than the electrical resistivities. The relative values at 1400° C. are about: copper, 1; graphite, 0·84; iron, 0·22; carbon, 0·17. *Electrode voltage.*—Iron is nearly as good as copper and much better than graphite although the difference seems to grow less at high temperatures. The relative values at 1400° C. are about: copper, 1; iron, 1·5; graphite, 5; carbon, 7·5. *Specific section.*—At 1400° C. the relative values are about: copper, 1; iron, 6·6; graphite, 14·6; carbon, 45. *Actual losses and sizes.*—The losses at temperature of 1400° are in the same ratio as the electrode voltage given above, and the sizes are in the same ratio as the specific sections.

C. O. B.

1024. *Preparation of Aluminium in the Laboratory.* **B. Neumann and H. Olsen.** (Zeitschr. Elektrochem. 16. pp. 230–236, April 1, 1910.)—After remarks on technical Al furnaces the authors describe laboratory apparatus of similar types, wrought-iron boxes provided with a bottom plate of Acheson graphite and an upper suspended electrode. The best yield of 70·4 per cent. was realised with a current density of 2 amps./cm.^{2}; this figure would depend upon the dimensions of the furnace. The addition of sodium chloride to the electrolyte answered only for low current-densities. H. B.

1025. *Nitrides and Oxides obtained by Heating Aluminium in Air.* **E. Kohn-Abrest.** (Comptes Rendus, 150. pp. 918–921, April 11, 1910.)—On plotting as co-ordinates the temperature and increase in weight of Al-powder heated in air for 10-minute periods a curve showing a maximum at 600° C. is obtained. At this temperature no nitrogen is absorbed, but after 2 hours' heating the oxygen-content becomes constant at 8·8 per cent. Attack by dry hydrochloric acid gas yields a chloride which does not quite correspond to the formula $AlCl_3$, and leaves an oxide similar to alumina, but containing more oxygen than is demanded by the formula Al_2O_3. At 800° C. some fixation of nitrogen occurs, but the nitride is decomposed on prolonged heating. Oxidation, however, continues even after 6 hours' heating. At 1100° C. the absorption of both oxygen and nitrogen is intense, the powder containing 22·5 per cent. nitrogen after 10 min., which content falls to 10 per cent. after 6 hours' heating, the total increase in weight being about constant after this time. Heating the dry powder in dry nitrogen showed that absorption commenced at about 750° C. The powder saturated with nitrogen at 900° C. was dark grey in colour, and stable up to 1100° C. in nitrogen. The proportion of Al : N was 2·14, while the formula AlN demands a ratio of 1·92. The nitride is completely decomposed after 2 hours' heating to 1100° C. in air. F. C. A. H. L.

1026. *Thermal Treatment of Copper Alloys.* **A. Portevin.** (Rev. de Metallurgie, 6. p. 814, 1909. Metallurgie, 7. pp. 188–189, March 22, 1910. Abstract of paper read befor the Internat. Congress of Applied Chemistry, London, 1909.)—Until the last few years quenching has been applied almost exclusively to steels, but study of the phenomenon has shown the intimate connection between the treatment and the critical points, and it appears that quenching can be applied to all alloys possessing critical points. Quenching an alloy from above the critical point results in a partial suppression of the change occurring on the line of the diagram; quenching from below the line is of theoretical importance only. The result of quenching is a change in the whole of the mechanical, physical, and electrical properties of the alloy, and is in most cases accompanied by a characteristic change in microstructure. The ordinary bronzes, containing from 9–81 per cent. tin, undergo the reaction: solution $\beta \rightleftharpoons$ eutectic $\alpha + \delta$. On quenching these alloys from above 550° C. the constituent β is obtained, and in a 8 per cent. alloy a decided improvement in the mechanical properties is effected. Aluminium bronzes containing 8–10 per cent. Al show an increase in tenacity on quenching from 750° C., a result of the suppression of the change occurring at about 500°. Annealing quenched alloys at the temperature of quenching removes the effects of quenching, while annealing the untreated material removes internal strains and renders the solid solutions homogeneous. Annealing cold-worked material is of great importance in the manufacture of cartridge cases, and it has been shown that the effects of annealing depend upon temperature, time, and the size of the materials. Microscopic analysis is a valuable asset in the thermal treatment of brass in the light of modern researches, which have shown the possibility of obtaining properties in Cu alloys, usually obtained by the addition of foreign metals, by thermal treatment. F. C. A. H. L.

1027. *Cobalt-Gold Alloys.* **W. Wahl.** (Zeitschr. Anorg. Chem. 66. 1. pp. 60–72, March 8, 1910.)—The methods of thermal analysis have been applied to this system of alloys. Alloys were prepared by melting the metals together in a porcelain tube heated in a carbon-tube furnace in an atmosphere of nitrogen. Cobalt and the Co-rich alloys attacked the porcelain tube consequent upon the slagging off of the impurities contained in the commercial Co. In addition, these alloys showed a tendency towards super-cooling. The equilibrium diagram shows that Co lowers the melting-point of Au, and Au that of Co, until the two branches of the curve meet in an eutectic point at a concentration of about 90 per cent. Au and a temperature of 997° C. Solid solutions are formed at both ends of the series, one containing 8·5 per cent. Au and the other about 94 per cent. Au. Cobalt undergoes a magnetic change-point at 1140° C., which is apparently not accompanied by a thermal change. The microstructures of the alloys confirm the results of the thermal analysis. All the alloys are magnetic, but the magnetic properties gradually diminish as the Au-content increases. The paper concludes with a table showing the properties of the alloys of Au with Co, Fe, and Ni.

F. C. A. H. L.

1028. *Metallographic Study of Zinc and the Principal Zinc-rich Alloys of the Metals occurring in Crude Zinc.* **P. T. Arnemann.** (Metallurgie, 7. pp. 201–211, April 8, 1910.)—Crude zinc contains Fe, Pb, Cd, As, Sb, Sn, Bi, and Cu as impurities, and since their quantitative determination occupies a great deal of time without giving much information as to their influence on the properties and structure of the zinc, the author has made a metallographic study of the binary systems with the object of applying the results to the micrographic examination of commercial zincs. The equilibrium diagrams of previous workers have been substantiated by the thermal analysis of the Zn-rich alloys. Samples from each series were then prepared for microscopic examination, either by casting in a wooden mould on the bottom of a heated carbon crucible, or by polishing and etching. Pure Zn possesses a polygonal structure, but the addition of 0·06 per cent. Fe causes a separation of crystallites of the compound $FeZn_7$. One per cent. Pb, 1 per cent. Cd, 0·5 per cent. As, 8 per cent. Sb, 0·1 per cent. Sn, 0·1 per cent. Bi, and

2·5 per cent. Cu can be readily detected microscopically. The principal impurities in Zn are Pb and Fe. Two crude zincs, the first containing 0·01 to 0·0088 per cent. Fe and 2·77 to 8 per cent. Pb, and the other 0·065 per cent. Fe and 1·5 to 1·7 per cent. Pb, were examined. The first showed the presence of Pb only, while in addition to Pb the second showed the crystallites of $FeZn_7$. The paper is illustrated by ten diagrams and fifty micrographs.

F. C. A. H. L.

1029. *Tensile Strength of Aluminium-Zinc Alloys.* **W. D. Bancroft.** (Mech. Eng. 25. pp. 329–330, March 18, 1910. Paper read before the Amer. Brass Founders' Assoc.)—The alloys were made by melting Al containing 99·9 per cent. Al with "Bertha Pure Zinc" which contained less than 0·2 per cent. impurities. When a thermo-couple introduced into the melt indicated that the temperature had fallen to 50° C. above the freezing-point as indicated on Shepherd's diagram, the alloy was cast into an ice-cooled graphite mould, the specimen being quenched in ice water immediately after solidification. Test-pieces prepared in this way showed very high tensile strengths (25,000–35,000 lbs. per sq. in.), the 60 per cent. Al alloy having the max. tensile strength at about 41,000 lbs. per sq. in. The ductility of the alloys was very low (below 5 per cent. elongation on 3-in. specimens), but was considerably increased by annealing, with a corresponding diminution in the tenacity.

F. C. A. H. L.

1030. *Solvent Power of γ-Iron for Iron Carbide in Iron-Carbon Alloys containing Manganese.* **H. Lütke.** (Metallurgie, 7. pp. 268–273, May 8, 1910.)—The position of the point E, representing the concentration at which the solid solution is saturated with cementite at the eutectic temperature (1130° C.) in the equilibrium diagram of the iron-carbon alloys, has been placed at concentrations varying from 1·2 to 2·1 per cent. carbon by various workers, but the recent work of Gutowsky [Abstract No. 688 (1910)] fixes it at 1·7 per cent. carbon. To determine the effect of Mn on the position of this point the author has prepared two series of alloys, containing about 5 and 10 per cent. Mn and from 1·5 to 4 per cent. carbon. The cooling curves showed that in both series the first appearance of eutectic occurred between 2 and 2·3 per cent. carbon. Microscopic examinations of slowly cooled and quenched small specimens indicated that the position of the point E was in the neighbourhood of 1·8 per cent. carbon, from which the conclusion is drawn that up to a concentration of about 10 per cent., Mn has little effect on the composition of the saturated solid solution. Other alloys, containing 2 to 8 per cent. carbon and up to 89·84 per cent. Mn, were then prepared and examined. The results showed that the carbon concentration of the solid solution is not appreciably increased until the Mn-content exceeds 49 per cent.

F. C. A. H. L.

1031. *Relations between Hardness of a Steel and the Temperature of Reheating.* **Grenet.** (Rev. de Metallurgie, p. 1054, 1909. Metallurgie, 7. pp. 223–224, April 8, 1910.)—The author has carried out experiments to determine if at a given temperature the effect of reheating approaches a limit. The results of reheating carbon and hard chrome-nickel steels show that at 800° C. the effect of heating is practically complete after 15 min., while at 500, 650, and 675° the effect is very slow after 4 hours, but is still incomplete after 16 hours. If the heating lasts longer than 15 min. the effect of the time is very small compared with that of the temperature. The effect of heating cold-hardened specimens is continuous, and increases with the temperature. In the neighbourhood of 800° the effect of the heating is to slightly increase the hardness induced by cold-hardening. F. C. A. H. L.

1032. *Nomenclature of Structural Constituents of Iron, Steel, and Pig Iron.* (Metallurgie, 7. pp. 65–71, Feb. 8, 1910.)—The following constituents of iron-carbon alloys were defined and the conclusions placed before the Internat. Assoc. for the Testing of Materials by the committee. The constituents fall into two groups; chemically homogeneous, defined as "Metarals"; and chemically heterogeneous, as "Aggregates." "Ferrite" is α iron containing less than 0·05 per cent. carbon and small quantities of other elements in solid solution. "Graphite" is identical with the mineralogical graphite. "Cementite" is a carbide of iron Fe_3C, and austenite a solid solution of carbon in γ iron, stable in the zone above the critical points. These four constituents are Metarals. "Pearlite" is an aggregate containing 0·9 per cent. carbon, and results from the decomposition of austenite into ferrite and cementite on slowly cooling through the critical ranges. "Martensite" is a solid solution of carbon in iron, which is metastable at all temperatures. It results from an incomplete decomposition of austenite, from which it differs by virtue of a greater magnetic permeability and hardness. "Osmondite" is a transition stage between martensite and pearlite, characterised by a max. solubility in acids and a max. colouration by etching agents. It is obtained by tempering martensite at 400° C. F. C. A. H. L.

1033. *Special Steels.* **W. Giesen.** (Iron and Steel Inst., Carnegie Schol. Mem. 1. pp. 1–59, 1909.)—In steels containing from 27 to 39 per cent. tungsten, cooled from 1320° C., Ar_3 does not exist, Ar_2 is sharply defined, and Ar_1 is split up. Under certain conditions, provided the initial temperature has been sufficiently high, Ar_3 may form the upper portion of the lower range of lag. The initial temperature necessary to depress the critical temperatures is principally a function of the tungsten percentage [see also Abstract No. 161 (1908)]. Heating at temperatures below the transition does not obliterate the lowering of the critical range. The tempering temperature of Cr-steels rises directly as the percentage of Cr is increased. The critical range is lowered inversely with the ratio of tempering temperature to percentage of Cr. The microscopic effects of alternating stress upon special steels are described, and resemble those found in carbon steels [see Abstract No. 1805 (1905)]. The views of Heyn and Bauer [Abstract No. 1488 (1906)] upon hardening and tempering are supported. F. R.

1034. *Study of the Ternary Special Steels.* **A. Portevin.** (Rev. de Metallurgie, No. 12. p. 1264, 1909. Metallurgie, 7. pp. 168–188, March 22, and pp. 211–215, April 8, 1910. Abstract.)—The author has studied the ternary steels containing Ni, Mn, Cr, W, Al, V, Si, Mo, B, and Ta by means of tensile and Frémont impact (shear) tests, and controlled the results by applying Frémont's formulæ to them. The results are influenced to a large extent by the structures of the alloys and serve to divide them into pearlitic, martensitic, and polyhedral steels. Frémont's formulæ, though applicable to ordinary constructional steels, do not apply strictly to ternary steels, and it does not appear that the results of impact tests can replace those of tensile tests. The relationship appears to depend upon the added element and the structure of the steel, and then holds good only between certain limits of load. The impact test is an important adjunct to the testing of special steels, since it characterises certain properties not observed by ordinary testing. The electrical resistance of these steels has also been studied in two series of each set of alloys, one containing 0·1 to 0·2 per cent. carbon and the other 0·8 per cent. carbon, in both the ordinary and quenched conditions. The results show that the laws connecting the electrical resistances with composition undergo sudden changes corresponding to the structural changes. In the pearlitic steels the resistance increases regularly with the percentage of added element; quenching these steels results in an increase of the resistance, owing to a retention of carbon in solid solution. In the martensitic steels the rate of increase of resistance is less than in the pearlitic steels. The low-carbon steels show practically no increase of resistance on quenching, but the high-carbon steels increase to a slight extent. The polyhedric steels are characterised by the addition of the third element causing a large increase in the electrical resistance. Quenching results in a very slight diminution in the resistance. Steels forming a double carbide increase only very slowly in resistance if the double carbide increases with the addition of the third element, but if the amount of double carbide is not increased, then the resistance increases rapidly with the added element. The effects of quenching these double carbide steels depends upon the exact nature of the constituents. Benedick's law, establishing a linear relationship between the resistance and the solid solutions of the foreign elements in the iron, $\rho = 7{\cdot}6 + 26{\cdot}8\Sigma C$ is only applicable to steels containing small quantities of the third element; in Ni-steels the limit is 2 per cent., and in W-steels 7 per cent. The effect of V and Ti on the critical points of the steels has been studied by the Saladin method. Titanium has very little effect on the Ar_1 point while vanadium causes a slight lowering. The paper concludes with a bibliography of the subject. F. C. A. H. L.

1035. *Action of Hydrogen and Nitrogen at various Temperatures on Iron containing Temper Carbon.* **F. Wüst** and **E. Sudhoff.** (Metallurgie, 7. pp. 261–264, May 8, 1910.)—The authors have carried out a number of experiments to determine if temper carbon is volatilised as hydrocarbons or cyanogen when heated in hydrogen or nitrogen respectively. An iron containing 2·79 per cent. carbon, 0·82 per cent. Si, and no graphite, was prepared and cast into bars, which were then annealed *in vacuo* at temperatures between 950° and 1030° C. in order to induce the separation of temper carbon. The specimens so obtained were heated for varying times and at varying temperatures in streams of specially purified hydrogen and nitrogen. Samples heated in hydrogen showed little or no change in the total carbon, but the combined carbon had increased at the expense of the temper carbon. Little or no change was observed in the specimen heated in nitrogen. Further experiments are in progress to determine the exact conditions of cementation by temper carbon. The paper is illustrated by four photomicrographs. F. C. A. H. L.

1036. *Alloys of Iron and Sulphur.* **M. Ziegler.** (Rev. de Metallurgie, p. 459, 1909. Metallurgie, 7. pp. 189–191, March 22, 1910. Abstract.)—Continuing previous work in conjunction with le Chatelier, the author has made a metallographic study of iron alloys containing sulphur. The work of Tammann and Treitschke [Abstract No. 1484 (1906)] has shown that only the compound FeS is formed in this system, and that the eutectic contains 80·91 per cent. S. Commercial sulphide of iron contains about 30 per cent.

S, and is therefore to be regarded as an alloy hypereutectic with respect to iron. The sulphide of iron examined contained 82·5 per cent. FeS and 17·5 per cent. impurities consisting mainly of oxide of iron and iron. In addition to the FeS-Fe eutectic and crystallites of iron, microscopic examination showed a third constituent, especially in very slowly cooled specimens. It proved to be a eutectic of the "second order," compounded of the two eutectics (FeS + Fe) and (FeO + Fe), which in the author's opinion plays a very important part in the red-shortness of steel. Alloys containing lower percentages of S showed a gradual diminution in the proportion of eutectic, until at a content of 0·08 per cent. S the eutectic vanished. This leads to the conclusion that a solid solution containing not more than 0·08 per cent. S exists. Soft steels (0·181 per cent. C and 0·874 per cent. Mn) to which varying proportions of sulphide of iron had been added were also examined. The sulphur was found to exist as the binary eutectic mixed with bluish-black flakes of the ternary eutectic. The flakes of sulphide exist almost wholly in the ferrite; in fact, the concentration of the sulphide is always least where that of the pearlite is greatest. In a steel containing 1·895 per cent. C and 1·888 per cent. S the sulphide was observed in two forms—(1) large round islands, and (2) small flakes scattered through the cementite. F. C. A. H. L.

1037. *Cementation of Silicon Steels.* **L. Grenet.** (Comptes Rendus, 150. pp. 921–922, April 11, 1910.)—The author has studied the cementation of steels with varying Si-content in different carbonising mixtures. Samples of two steels, one an ordinary case-hardening steel containing 0·11 per cent. Si, and the other a steel of similar composition except that the Si-content was 8·20 per cent., were case-hardened for 12 hours in (*a*) calcined wood charcoal, (*b*) ordinary wood charcoal, and for 6 hours in (*c*) yellow prussiate of potash. The carbon-content of the outer layer, 0·5 mm. in thickness in the three samples after cementing, was as follows:—

	a.	*b.*	*c.*
Case-hardening steel	0·85	1·00	1·48
Silicon steel	0·09	0·17	1·05

These results justify the practice followed in some works of case-hardening grey cast iron by heating in cyanide products. The carburised Si-steel shows no graphite on microscopic examination, and the sample shows no graphite separation even after heating to 800° C. for 15 min. Quenched from this temperature the steel is quite hard, and shows a martensitic structure in the case. F. C. A. H. L.

1038. *Impact Tests at High Temperatures on Ordinary and Special Steels.* **L. Guillet** and **L. Revillon.** (Rev. de Metallurgie, 6. p. 918, 1909. Metallurgie, 7. pp. 273–275, May 8, 1910. Abstract.)—A number of tests have been carried out to determine the influence of the velocity of impact and of various elements on the resilience curve plotted as a function of the temperature. Three series of tests with different impact velocities were made in a Guillery machine on a steel containing, in per cent., 0·35 carbon, 0·20 Si, 0·048 sulphur, 0·068 phosphorus, and 0·51 Mn, and which had previously been annealed in a closed box for half an hour at 850° C. The results indicate the existence of a maximum in the curve between 110° and 160°, and a minimum between 460° and 480°. Further tests were carried out on special steels corresponding to definite microstructures, and included a pearlitic nickel-chrome steel, a pearlitic steel on the border of the martensitic state, a martensitic steel, a steel on the border between martensite and γ iron, a γ-iron steel and a steel containing 5 per cent. tungsten. The martensitic steels gradually increased in resilience up to 580°, but appeared to pass through a maximum at about 150–170° C. The polyhedric γ-iron steel gradually decreased in resistance to shock as the temperature rose.

F. C. A. H. L.

1039. *Influence of Pressure on Electrolytic Conductivity of Solutions.* **F. Körber.** (Zeitschr. Phys. Chem. 67. 2. pp. 212–248, July 23, 1909.)—Experiments are described on the effect of pressure on the conductivity of electrolytes on the lines laid down by A. Bogojawlensky and G. Tammann in 1898. As a rule the resistance decreases on compression, but in many cases a minimum is reached, and further compression causes an increase. This is seen in the case of solutions of potassium chloride at all temperatures from 0° to 100°; at 0° the minimum amounts to 0·872 of the original value, and is just reached within the limiting pressure of 3000 kg. per cm.^{2}; at 100° the lowest resistance, at 900 kg. per cm.^{2}, is 0·998 of the original, the ratio rising to 1·014 at 3000 kg. per cm.^{2}. Amongst the halogen compounds the largest decreases of resistance are found in the case of hydrogen chloride (17 per cent. for $v = 100$, $p = 3000$, $t = 19°$) and lithium chloride (14 per cent.), then follow potassium chloride, sodium chloride, potassium bromide, sodium bromide, potassium iodide, and sodium iodide (9, 8, 6, 5, 2, and 1 per cent. respectively), the order of increasing atomic weights being broken in the case of sodium and potassium; minima of resistance at intermediate pressures appear, and become more and more pronounced, in the curves for the last six salts; for their dilute solutions the effects are additive. The curves give the impression that (as in the case of gaseous compressibilities) two opposite factors are at work, one of these producing a decrease, and the other an increase, of electrical resistance on compression.

T. M. L.

1040. *Thermal Properties of Silver Nitrate.* **Guinchant.** (Comptes Rendus, 149. pp. 569–571, Oct. 4, 1909.)—From the value, 17·6 cals., previously found [Abstract No. 1938 (1907)] for the latent heat of fusion of silver nitrate at 209°, the cryoscopic constant of this salt is calculated to be 264. A large number of salts dissolve in silver nitrate, and those which have a radical common with it do not give rise to double decomposition and allow of cryoscopic measurements. The values of K thus obtained are: For lithium nitrate, 262; potassium nitrate, 260; thallium nitrate, 260; lead nitrate, 288; silver chloride, 278; silver iodide, 305; silver fluoride, 249; silver iodate, 290, and silver sulphate, 289. The molecular depression of the freezing-point of silver nitrate is hence normal, and also varies but slightly with the concentration of the dissolved salt. The author has further investigated the marked expansion which accompanies the transformation of rhombohedral silver nitrate into the rhombic modification at 159°, the following values being obtained: Coefficient of expansion at 20–150°, 77×10^{-6}; contraction at 159° on raising the temperature, 0·17 per cent.; expansion at 159° on lowering the temperature, 0·22–0·25 per cent.

T. H. P.

1041. *Relation between Viscosity and Chemical Constitution.* IV. *Viscosity and Hydration in Solution.* **A. E. Dunstan** and **F. B. Thole.** (Chem. Soc., Journ. 95. pp. 1556–1561, Oct., 1909.)—In accordance with the fact that viscosity increases with molecular weight and is always great in associated liquids, it has been usual to attribute to the formation of hydrates or similar complexes the maxima of viscosity which are sometimes observed in mixtures of two liquids. These maxima need not, of course, be sharp or abrupt, but it is a point of some importance that the position of the maximum on the scale of concentrations should be independent of the temperature. On this point the evidence has been conflicting: Arrhenius and Traube noticed considerable variations in mixtures of alcohols and water at various temperatures, but on the other hand Getman found the maximum for methyl alcohol and water to be constant over a range of 68°. Moreover, a constant position of the maximum has been found by Wijkander for acetic acid and water, by Domke and Bein and by Kremann and Ehrlich for sulphuric acid and water (H_2SO_4, H_2O) over a range of 75°, and for aniline with phenol or cresol over a range of 88°. The authors have tested the point by a careful study of aqueous solutions of methyl, ethyl, and propyl alcohols and acetic acid at 20°, 25°, and 30° C., and find that in each case the composition of max. viscosity agrees closely with that of the monohydrate, and is independent of the temperature of experiment. The temperature-coefficient of viscosity, which for four non-associated liquids has a value 0·00045 to 0·00058, rises in the case of methyl alcohol to 0·00127, ethyl alcohol 0·00321, propyl alcohol 0·00965, and propionic acid 0·00338, and may thus be used as a test for association and dissociation. In accordance with this view the temperature-coefficients for the monohydrates (mixtures of max. viscosity) are found to be for aqueous acetic acid 0·006114, methyl alcohol 0·00587, ethyl alcohol 0·00780, propyl alcohol 0·00900. T. M. L.

1042. *Interdependence of the Physical Properties of Solutions.* I. *Density and Electrical Conductivity of Aqueous Salt-solutions.* **A. Heydweiller.** (Ann. d. Physik, 30. 5. pp. 873–904, Dec. 14, 1909.)—For the great majority of strong electrolytes there is a linear relationship between the equivalent conductivity (or coefficient of ionisation) and the increase of density in the solution as compared with water at the same temperature. It is therefore possible to distinguish the effects produced by the un-ionised part of the solute from those produced by the ions, and these are shown to obey very closely an additive law of specific volumes. Deviations are found in the case of ammonium and potassium salts (increase of volume on dissolution) and certain salts which separate with water of crystallisation and show a contraction on dissolution. Ionisation is always accompanied by an increase of density, depending probably on a contraction of the water; the contraction increases rapidly with the sum of the ionic mobilities, and is additive for the two ions. Exceptions to the fundamental linear law are found in substances which form complex ions or a long series of hydrates. T. M. L.

1043. *Viscosity of Liquids as a Function of Temperature.* **M. Brillouin.** (Annal. Chim. Phys. 18. pp. 197–218, Oct., 1909.)—Attention is called to the fact that Slotte's formula for the influence of temperature on viscosity $\eta = c/(a + t)^n$ which was adopted by Thorpe and Rodger in their Bakerian lecture has the disadvantage that the constant n cannot be accurately determined by experiment: the use of an average value 1·75 would almost serve, so little does this constant affect the "fit" of the curve, but at the same time the errors would exceed those due to experiment. The author advocates the use of the parabolic formula of Graetz $\eta = A\,[(t - t_0)/(t - t)]$, which was rejected by Thorpe and Rodger on the ground that it could not be applied to water or to the alcohols. Calculations based on this formula have shown an excellent agreement in the case of liquids such as the hydrocarbons, which are not anomalous in other respects, and this agreement extends right up to the boiling-point. Substances like water and the alcohols, which exhibit anomalous surface tensions at low temperatures (compare Ramsay and Shields) also exhibit large deviations from the formula of Graetz, both anomalies being doubtless due to polymerisation. For substances of high molecular weight and complex constitution the formula $\eta = AT^{\frac{1}{2}}[(t - t_1)^2 + c]/[(t + t_0)^2 + c']$ is suggested, where T is the absolute temperature. This expresses the viscosity over the whole range for a substance like dimethylethylcarbinol, which required the use of 3 separate curves (0 to 27°, 27 to 63°, 63 to 95°), and nine constants when Slotte's formula was used. The hyperbolic formula now advocated for viscosity may be compared with the linear formula for fluidities recently proposed by Bingham and Harrison [Abstract No. 2160 (1909)]; a detailed examination would probably show that they were identical in their essential features. T. M. L.

1044. *Solvent Effect of Ferric and Cupric Salt Solutions upon Gold.* **W. J. McCaughey.** (Amer. Chem. Soc., Journ. 31. pp. 1261–1270, Dec., 1909.)—Gold is soluble in hydrochloric acid solutions of iron alum and of cupric chloride. The rate of solubility increases more with an increase in concentration of acid than with an increase in concentration of the salt. Particularly is this so in the case of the copper salt. With an increase in temperature from 38–43° to 98–100°, the rate of solubility increases eleven times in the case of iron alum, and thirty-two times in the case of copper chloride. By doubling the concentration of acid at 38–43° the solvent action of cupric chloride solutions is increased seven times; at 98–100° it is increased five times. In the case of copper chloride the solubility of gold apparently does not approach a limit. The amount of gold dissolved is proportional to the time, and there is apparently no decrease with time in the amount dissolved as in the case of the iron salt. T. S. P.

1045. *Dissociation Isotherms of Sulphur between 300° and 850°.* **G. Preuner** and **W. Schupp.** (Zeitschr. Phys. Chem. 68. 2. pp. 129–156, Nov. 9, 1909.)—By means of a quartz-glass manometer the authors have measured the density of sulphur vapour at nine temperatures between 300° and 850° and within wide limits of pressure. The results indicate that at pressures above 30 mm. only S_8, S_6, and S_2 molecules are present; below 30 mm. there may be a small proportion of S_1 molecules. It requires about 20,000 cals. to change 8 × 32 gm. of solid sulphur into gaseous S_8 molecules, and a further 95,000 cals. to break these down to S_2 molecules. On the assumption that S_8 and $S\mu$ (the modification insoluble in CS_2) are identical, the proportion of $S\mu$ in saturated sulphur vapour may be calculated; the values will be found to agree with those found analytically by Gal in 1893. The dissociation of H_2S is investigated in a similar manner in a separate paper (Ibid. pp. 157–168). D. H. J.

1046. *Zinc Amalgams.* **E. Cohen** and **K. Inouye.** (Zeitschr. Phys. Chem. 71. 5. pp. 625–635, Feb. 25, 1910.)—The authors have determined the solubility of zinc in mercury at different temperatures from 0° to 100°. These results yield an unbroken curve, but it is observed that electrometric measurements, the results of which are promised later, point to the solubility relations being more complicated than the solubility measurements indicate. The previous determinations by Kerp and Böttger and by Puschin are shown to be erroneous. A. F

1047. *Electromotive Properties of the Oxides of Mercury.* **A. J. Allmand.** (Zeitschr. Elektrochem. 16. pp. 254–268, April 15, 1910.)—The author has carried out investigations of the e.m.f. of mercuric oxide-alkali cells, and reaches the following conclusions: (1) The differences of potential values in the case of the system Hg | HgO-alkali | are due entirely to differences in the size of particles of the depolariser. (2) Red and yellow mercuric oxide are not isomeric but identical, and give analogous potential values if the influence of size of particle is excluded. (3) The values for the electrode potentials $Hg_2^{\cdot\cdot} \longrightarrow 2Hg$ and $Hg^{\cdot\cdot} \longrightarrow Hg$ must be 0·025 volt higher than hitherto assumed, viz., + 0·775 and + 0·835 volt. (4) The solubility product of mercuric oxide is 4×10^{-26} at 18°. (5) The dissociation pressure of mercuric oxide at 18° is 6×10^{-22} atmo.—a number not in harmony with that calculated by the Nernst equation. (6) The free energy of formation of mercuric oxide at room temperature is 14,250 cals. (7) Mercurous oxide does not have definite electromotive properties on account of its tendency to pass into mercuric oxide. (8) The system Hg | $HgO_1 n$ — NaOH | forms an excellent standard electrode. A. F.

1048. *Voltaic Cells with Combustibles.* **I. Taitelbaum.** (Zeitschr. Elektrochem. 16. pp. 286–300, May 1, 1910.)—The author has studied various cells where the current is yielded by the combustion process. The cell was of passive iron forming the kathode, the kathode space being filled with pyrolusite. A diaphragm of lime was employed. The anode was a carbon tube. Fused manganate was used as depolariser. Various combustible substances were employed, hydrogen, CO, sugar, tallow, brown coal, black coal. The experiments, however, do not point to such cells being made practically useful. The author also carried out experiments with sulphuric acid as electrolyte and various salts as oxygen-carriers, the potentials obtained being determined. A. F.

1049. *Energy of a "Double-layer" Condenser of Electronic Origin.* **W. C. McC. Lewis.** (Phil. Mag. 19. pp. 573–575, April, 1910.)—The author summarises the p.d.'s observed between colloidal particles and the medium, and points out that they are all of the same order of magnitude. As regards the explanations put forward for the existence of a p.d.—the electrolytic and electronic explanations—the electrolytic explanation is open to a number of objections, the chief being that colloidal solutions can be prepared from substances with which it is extremely unlikely to suppose electrolytic ions associated—such, for example, as colloidal Pt in chloroform. The author favours the electronic view. He also points out a relationship which appears to hold between the electrostatic energy of the double layer and the kinetic energy of the electrons. Supposing an electron to escape from the colloid particle and to come to rest after traversing the distance corresponding with the thickness of the double layer. The decrease in kinetic energy is $\frac{1}{2}mv^2$. The increase .in electrostatic energy is $\frac{1}{2}\pi e$. Equating these $\pi = mv^2/e$, from which π is found to be equal to 0·048 volt, which is in fair agreement with the observed p.d. of colloidal metals. A. F.

1050. *Transport-number of Hydrochloric Acid.* **E. H. Riesenfeld** and **B. Reinhold.** (Zeitschr. Phys. Chem. 68. 4. pp. 440–458, Dec. 14, 1909.)—A new series of values is given for the transport-number of hydrogen chloride over a range from normal to decinormal. These values indicate clearly the existence of a minimum at a concentration of about 0·7N, the value falling at this point to 0·154 as compared with 0·38 at 10N and 0·155 at normal concentration. At decinormal concentration the value rises to 0·161, but at greater dilutions the values recorded by various observers are irregular, and it is not possible to fix the value for infinite dilution within narrower limits than 0·168 to 0·172; the value deduced from conductivity data, 0·172, agrees exactly with the latter figure. T. M. L.

1051. *Calculation of E.M.F.'s from Thermal Measurements.* **A. Magnus.** (Zeitschr. Elektrochem. 16. pp. 273–275, April 15, 1910.)—If the free energy A of a reaction is given as a function of the absolute temperature T, the heat of reaction Q is given by the equation $Q = A - T \, . \, dA/dT$. If, on the other hand, Q is given as a function of the temperature, the equation with an infinite number of solutions is obtained, $A = -T \int \frac{Q}{T^2} dT + CT$. By adopting the Nernst theorem regarding the connection between A and Q the author has shown how the above equation can be solved and values for the specific heats of substances calculated which agree very well with the experimental numbers. A. F.

1052. *Determination of Transport-numbers from E.M.F.'s in Solvents only partially Miscible with Water.* **E. H. Riesenfeld** and **B. Reinhold.** (Zeitschr. Phys. Chem. 68. 4. pp. 459–470, Dec. 14, 1909.)—The transport-number for certain salts dissolved in phenol has been determined by measuring the e.m.f. of concentration cells in which the two solutions in phenol were covered with solutions in water, *e.g.*, of N/10 and N/100 strength, and so brought into contact with normal calomel or mercurous bromide electrodes. In previous experiments large errors were introduced owing to the fact that the water and phenol were not in equilibrium with one another; this error was eliminated in the experiments now described, and it is shown that potassium chloride and bromide give values 0·489, which (in contrast to the earlier value, 0·196) are in agreement with a rough value 0·475 deduced by Hittorf's method. T. M. L.

1053. *Some Minute Phenomena of Electrolysis.* **H. W. Morse.** (Amer. Acad., Proc. 45. No. 15. pp. 371–376, April, 1910.)—The author has observed certain minute phenomena that accompany electrolysis in which lack of equivalence at the electrodes is especially evident. So far only qualitative observations have been made. If pure water be electrolysed between small silver electrodes at voltages ranging from 1·40 to about 3·8 volts, and the space between and about the electrodes be observed under the microscope with powers of 50 or so, the following phenomena may be seen. A very short time after the circuit is closed a cloud of very small brownish particles, in rapid Brownian movement, is formed near the anode. A silver-foil anode dissolves rapidly, and a dark film of silver oxide remains. The particles first make their appearance at a slight distance from the anode, and appear to be due to the formation of a silver compound produced from the silver which has dissolved and one of the constituents of the water. This cloud consists of approximately spherical particles of diam. 0·8–1·0 μ; the particles appear to be silver oxide. A thin cloud, the particles of which are metallic in appearance, *may* also appear about the kathode, only to disappear suddenly later on, when the growth of metallic Ag begins at the front of the kathode

The above-described effects appear in the purest obtainable water, and they are most evident in the best conductivity water. Electrolytes in very small concentration prevent the effect completely, and cause the appearance of the usual gas-bubbles at the anode and kathode. While the above effects are making their appearance in the electrolyte nothing whatever happens at the kathode itself. The space between the electrodes may be active for several minutes without the appearance of either a bubble of gas or a crystal of Ag. A magnetic field has no definite effect on the particles. An adaptation of the microbalance was used to follow the changes in weight at each electrode during the electrolysis, with the following qualitative results: Immediately on closing the circuit a very slight *decrease* in the weight of each electrode was observed in 4 out of 6 experiments. Thereafter for several min. an *increase* in weight of each electrode took place, the anode gaining much faster than the kathode. The increase in weight of the anode is due to the formation of silver oxide or peroxide; that of the kathode to the deposition of Ag. Finally, there is a decrease in weight at the anode and increase at the kathode. T. S. P.

1054. *Electrolysis of Fused Sodium Chloride.* **C. F. Carrier, Jr.** (Metallurgical and Chem. Engin. 8. pp. 253–257, May, 1910.)—The author describes experiments, begun at the Technical College in Karlsruhe in 1909, and continued by the Elmira Electrochemical Co., but finally given up, undertaken with the object of working out a Castner process with fused salt, in which lead amalgam would replace the mercury amalgam, and sodium would secondarily be liberated from the lead amalgam. The first experiments were made with a rocking cell, built up of sheet iron and cement; the latter fouled the electrolyte. In the larger furnaces tried later the amalgam was circulated by means of a piston pump; this attempt failed. Finally a continuous-flow furnace was constructed, in which a cast-iron propeller at 600 r.p.m. maintained the circulation. The electrolyte ($3NaCl+3KCl+2CaCl_2$) was preheated by gas-burners, and further by additional graphite rods driven into the face of the anode blocks; when the bath was liquid, these special rods were removed. The kathode compartment was first filled with fused caustic soda; but no Na was liberated from that bath, which was afterwards replaced by the mixture mentioned. Although this decomposition yielded an amp.-hour efficiency of 80 per cent., the author recommends the preparation of sodium peroxide and of cyanide from the lead amalgam. [Compare Abstract No. 388B (1907).] H. B.

1055. *Electrolysis of Aqueous Solutions of Sodium Bromide. Retardation of the Anodic Liberation of the Halogens.* **F. Foerster** and **J. Yamasaki.** (Zeitschr. Elektrochem. 16. pp. 321–355, May 15, 1910.)—The authors study the electrolysis of aqueous solutions of sodium bromide under different conditions in a glass beaker of 300 cm.^{3} with concentric cylindrical electrodes of Pt-wire gauze, platinised after Lummer and Kurlbaum or smooth; the stirrer was driven by a small electric motor. They confirm, on the whole, the views of H. Kretzschmar [Abstract No. 277 (1905)]. The primary product at the anode is formed by Br' and also by OH'; the Br unites to hypobromite with the caustic soda formed at the kathode. The hypobromite is oxidised to bromate in one of two ways: in originally neutral solutions by the hypobromic acid produced near the anode (this by purely chemical reactions); in alkaline solutions electrochemically by oxygen liberated at the anode. The anodic discharge of Br' does not proceed in a perfectly reversible manner, when oxygen is also formed anodically. Presence of oxygen in the platinised coating retards the discharge of bromine, and raises the potential required for it. This retardation is, as F. Boericke had already observed, particularly noticeable with smooth Pt electrodes. Platinum oxides appear to retard, in a still obscure way, the transition of the primary product arising from the halogen ions, the *status nascendi* of the halogens, into free molecules. Reference as regards this point is made to R. Luther, F. J. Brislee, and G. Pfleiderer. H. B.

1056. *Rapid Electro-analysis with Stationary Electrodes.* **T. S. Price** and **T. C. Humphreys.** (Soc. Chem. Ind., Journ. 29. pp. 307–309; Discussion, p. 309, March 31, 1910.)—The authors have made a number of experiments with the object of checking Stoddard's results [Abstract No. 757 (1909)], the accuracy of which could not be determined, as the weights of metal taken were not given. From the results obtained, it is concluded that, for rapid electro-analysis, stationary electrodes are not so reliable and satisfactory as rotating electrodes. In the case of silver they do not give accurate results, and there is some uncertainty with the deposition of zinc. One great disadvantage is that a tap-funnel cannot be used to hold the electrolyte, owing to a portion of the latter remaining in the neck of the funnel and so escaping electrolysis; attempts are being made to adapt a tap-funnel for use with stationary electrodes. T. H. P.

1057. *Attempts to Separate Uranium and Uranium X by Electrolytic Methods and by Kathodic Disintegration.* **G. v. Sensel.** (Zeitschr. Phys. Chem. 71. 5. pp. 563–570, Feb. 25, 1910.) [See Abstract No. 1266 (1908).]—The electrolytes from which the author attempted to separate UrX were uranyl oxalate, acetate and nitrate. The voltages used varied from 0·05–1·5 volts, and the time of electrolysis from 1–170 hours. Copper-foil electrodes were used, the one side being coated with paraffin wax. The activity of the deposit, which was slowly dried, was measured by means of a Schmidt-Kurz electrometer. In no case was pure UrX obtained, although the amount present in the deposit was generally in excess of the equilibrium quantity. With the oxalate electrolyte the excess was 7·1–14·1 per cent.; with the acetate electrolyte, 4·3–4·5 per cent. In the case of the nitrate electrolyte no excess of UrX over the equilibrium quantity could be detected. In the experiments on kathode disintegration the discharge tube contained a beaker-shaped hollow kathode, in which the material to be investigated was placed. Opposite to the kathode was a copper disc, the distance of which from the kathode could be varied. The material used was black uranium oxide, which had been well heated and compressed. It was found that the copper disc became active when a discharge was passed through the tube, so that disintegration of the uranium oxide undoubtedly took place. Continuous observation over a period of forty-three days showed that the activity remained constant, the Ur and UrX being present in the equilibrium quantity. UrX cannot, therefore, be obtained pure, either by electrolysis or by kathodic disintegration. T. S. P.

1058. *Mercury Kathode in Rapid Electro-analysis.* **W. S. Kimley.** (Amer. Chem. Soc., Journ. 32. pp. 637–641, May, 1910.)—For use with a mercury kathode the author replaces the small tube used by Kollock and Smith by a wide-necked round-bottomed flask of about 125 c.cm. capacity. An arrangement is also described for adapting an ordinary straight-sided weighing bottle for use with a mercury kathode, the current connection being made by means of a Pt-wire sealed in a glass tube. The analysis of alloys containing Cu, Pb, Zn, Sn, and Te is described. For copper determinations a mercury kathode is superior to one of Pt when the electrolyte is strongly acid with nitric acid. Antimony and tin cannot be quantitatively deposited as amalgams. Zinc is one of the metals that is best determined as an amalgam, since when deposited on Pt it is difficult to remove without rendering the Pt black and spongy. T. S. P.

REFERENCES.

1059. *Absorption and Adsorption with reference to the Radio-active Emanations.* **R. W. Boyle.** (Bulletin of the Macdonald Physics Building, McGill University, No. 1. pp. 1–59, April, 1910.)—An extensive thesis on the absorption of radium and thorium emanations by charcoal and by various liquids [see Abstracts Nos. 1632 (1908) and 187 (1909)]. E. M.

1060. *Heat of Solidification of the Lead-Tin Alloys.* **D. Mazzotto.** (N. Cimento, 19. pp. 215–232, March–April, 1910.)

1061. *Application of High-pressure Gas to Furnace Use.* **A. W. Onslow.** (Soc. Chem. Ind., Journ. 29. pp. 395–397; Discussion, pp. 397–398, April 15, 1910.)

1062. *Combustion-temperature of Carbon in Blast-furnaces.* **C. P. Linville.** (Amer. Inst. Mining Engin., Bull. 39. pp. 237–248, March, 1910.)

1063. *Bearing Metals and Stamping Alloys.* **W. Guertler.** (Metallurgie, 7. pp. 264–268, May 8, 1910.)—Working on somewhat similar lines to those described by Friedrich [Abstract No. 631 (1910)], the author has prepared bearing metals and alloys for stamping to complicated shapes, by mixing a powdered soft metal such as lead with a hard metal like iron, steel, spiegeleisen, &c., heating to 250–300° C. and then pressing to any desired shape. If the products are sound their mechanical properties compare very favourably with those of the corresponding true alloys. F. C. A. H. L.

1064. *Corrosion of Iron by Water and Aqueous Solutions.* **E. Heyn** and **O. Bauer.** (Königl. Materialprüfungsamt, Mitt. 28. 2 and 3. pp. 62–137, 1910.)—The authors have continued their work on the corrosion of iron [see Abstract No. 1189 (1908)], and from theoretical considerations have concluded that the corrosion of iron is not a case of pure solution. A comparison of the corrosion of wrought iron, cast iron, and steel shows very little difference between the three varieties tried. The effects of agitation and temperature of the water, and solutions of numerous metallic salts both simple and mixed, on the corrosion of iron has been studied at some length. F. C. A. H. L.

1065. *Past and Future of the Study of Solutions.* **L. Kahlenberg.** (Science, 31. pp. 41–52, Jan. 14, 1910. Address to Chemical Section of the Amer. Assoc. for Advancement of Science, Boston, 1909.)—The chemical theory of solutions is advocated, according to which the whole of the solute is combined with the whole of the solvent, though some part of the solvent (water of crystallisation, &c.) is more firmly combined than the rest. T. M. L.

1066. *Current Densities and Energy Losses in Electrodes.* **J. Forssell.** (Metallurgical and Chem. Engin. 8. pp. 26–33, Jan., 1910.)—Gives a theoretical analysis of the different factors influencing the energy losses in electric furnace electrodes. The paper deals with the subject largely from the mathematical point of view and is unsuitable for a brief Abstract. C. O. B.